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# THE HEART AND THE RED BLOOD CELLS AS GENERATOR AND DISTRIBUTORS OF STATIC ELECTRICITY

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## I. A THEORETICAL CONCEPTION

Physiologists are agreed that electric stimulation is the equivalent of physiological stimulation.

Any substance moving through air or through water takes on static charge, and the charge is related to the speed of the movement.

The red blood cells are ideally evolved as receptors and carriers of static charge. This is seen in the extreme thinness of their covering films ($\frac{1}{2,500,000}$ cm. thick), in their biconcavity, which provides a larger surface per mass, and in their irregular shape, which increases tumbling and friction and thereby produces higher charge.

The irregular cavities of the heart and the heart's contractions form an ideal mechanism for friction and movement, required for accumulating static electricity. The highest electric charge would be expected in the left ventricle, the lowest in the vena cava, since electric charge is highest with the maximum speed of movement. As the red blood cells slow down in passing from the left ventricle to the capillaries, the electric charge is distributed to the walls of the blood vessels and to the tissues beyond. The greatest distribution would therefore occur in the capillaries, where the movement of the red blood cells is extremely slow.

The heart as a generator and the red blood cells as distributors collaborate to stimulate electrically every tissue and organ of the body. As each contraction of the heart contributes electrical stimulation to the entire arterial tree, it establishes

peripheral resistance in the arterial system, required for the proper circulation of the blood. Thus the heart and the red blood cells contribute to the tone and the physiological activity of the entire organism.

The heart responds instantly to various simulations of the environment, such as danger. This response occurs through the special senses, the stimulus passing from the brain over the sympathetic nerves down to the junction between the celiac ganglion and the aortic wall. This junction would seem to be the point of communication between the external and the internal environment of the animal, analogous to the countless nerve end plates between the voluntary nerve fibers and voluntary muscle fibers, which are synaptic junctions between the internal and external environment.

With each pulse of the heart a wave of electrical stimulation is distributed to the vascular walls of the entire arterial tree. Thus the heart contraction sets up its own peripheral resistance, and this resistance sets up stimulating mechanical pressure in turn on the walls of the heart. This would appear to be an important factor in circulation of the blood.

It would appear that the celiac ganglion is the mediator between the sense stimuli of the environment and the electrifier of the organism, the heart and the red blood cells, with their power of generating and distributing static electricity. These conceptions have been tested in the Biophysics Laboratory of the Cleveland Clinic Foundation by Dr. Otto Glasser and Dr. D. P. Quiring

## II. Potential Gradients of the Blood and Organs of Certain Mammals

Living organisms have electrical properties. One of these properties is the potential gradient which exists between different organs. This potential gradient lends itself to accurate measurement, and it is characteristic for the organism under investigation and also for the condition it is in at the time of the experiment.

For the determination of potential gradients in living organisms, we have built a microvoltmeter on the general principles suggested by Burr and Lane.[1] This instrument is

[1]Burr, H. S., C. T. Lane, and L. F. Nims: A Vacuum Tube Microvoltmeter for the Measurement of Bioelectric Phenomena. Yale J. Biol. & Med. 9: 65–76, 1936.

sensitive and stable and draws a minimum amount of current from the tissue. It consists of a balanced bridge circuit which permits detecting voltage gradients as small as a few microvolts. Contact between the instrument and tissue is made by two reversible, nonpolarizable silver-silver chloride electrodes. These are immersed in a balanced physiological saline solution and are connected through glass and rubber tubing to two glass pipets which are in turn inserted into the tissue. These glass pipets may be variously shaped, depending upon the organs into

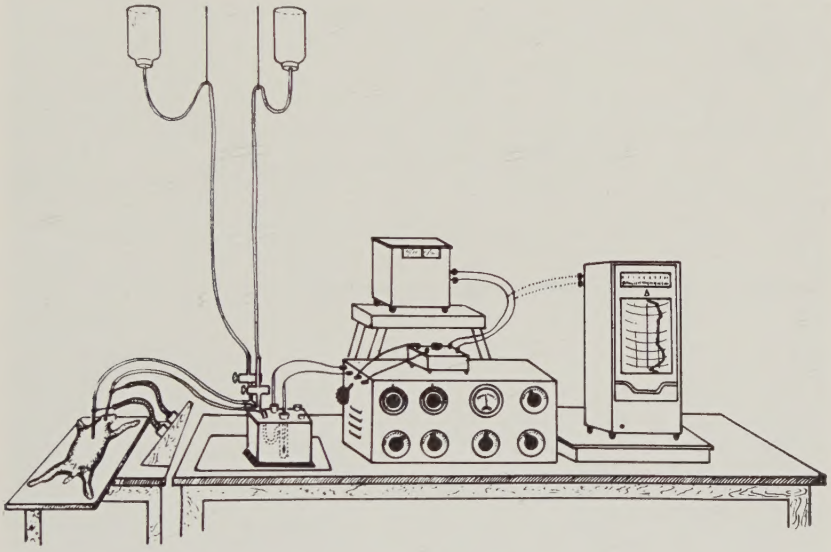

Fig. 1. Microvoltmeter to measure potential gradients in animals.

which they are to be inserted. Readings are taken on a sensitive bridge galvanometer which is directly calibrated in microvolts. For single readings, a Rubicon galvanometer with a sensitivity of about 0.0032 micro-amperes per division, and for continuous records, a General Electric photoelectric recording galvanometer with a sensitivity of about 0.02 micro-amperes per division, were used. Figure 1 shows a schematic diagram of the apparatus.

With this microvoltmeter, potential differences were measured between various points in a series of 265 animals, 245 of which were rabbits. In practically all the animals we used the retina of the eye as the location for one of the pipet-electrodes,

after it was determined that for these measurements the eye acts as part of the brain. The location of the other pipet-electrode was generally the lumen of the left ventricle of the heart, and in selected cases also the kidney, liver, adrenal gland, bladder, genital organs, rectum, ileocolic junction, stomach, duodenum and spleen. The electrodes were inserted while the animal was under ether anesthesia.

Some significant general observations were made. With blood circulating through it, the polarity of the left ventricle

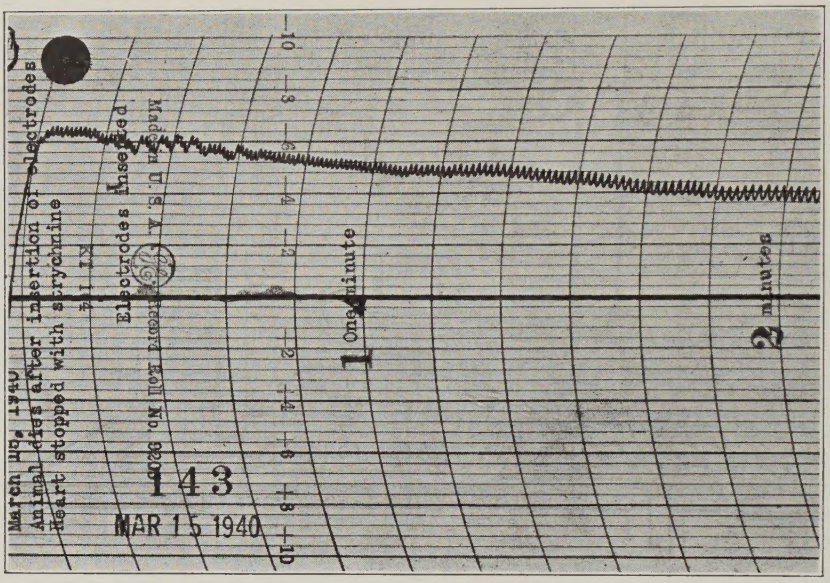


Fig. 2. Death curve in normal rabbit. Interval of time, 10 seconds.

was always negative compared to that of the brain. The polarity of all other organs of the normal animal was also negative compared to that of the brain, with the exception of the stomach.

The potential gradient between eye and left ventricle in almost 200 rabbits was determined to be $2.28 \pm 0.038$ millivolts.

The potential gradient between eye and right auricle in 10 animals measured $1.18 \pm 0.073$ millivolts.

If the animal continues to live after the electrodes have been inserted, the potential gradient is essentially maintained during life. If death occurs, the gradient decreases more or less

rapidly. Our experiments have taught us again that it is difficult to determine the exact time of tissue death. Generally, cessation of breathing is referred to as death. However, that does not mean that the other organs of the animal stop functioning at the same time. Many of our records show that after breathing stops, the heart continues to beat for a long time. If the heart slows down, the beats superimposed upon our potential

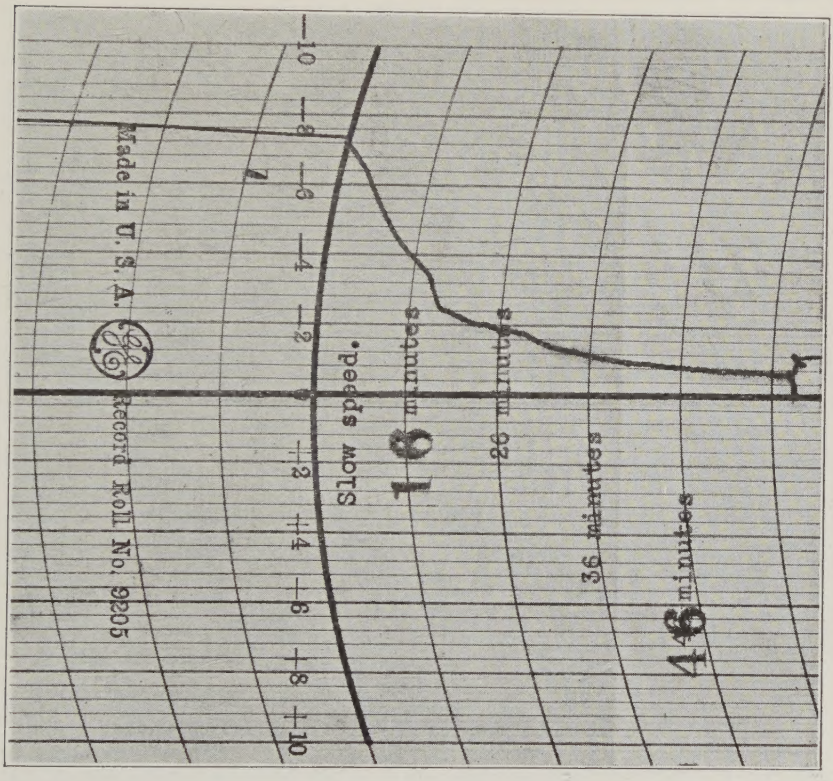


Fig. 3. Death curve in normal rabbit after injection of 2 cc. of chloroform into heart. Interval of time, 10 minutes.

gradient curves continue in many cases even after the main potential difference between heart and eye has disappeared. All other organs also show definite potential gradients long after death, although all of them decrease more or less rapidly after breathing stops. The organs which lose their potentials quickest are the liver and the brain. Then follow the adrenal glands and the organs of the genito-urinary and gastrointestinal tracts.

The kidney potentials seem to be the most stable, and the kidney therewith the longest lived organ of those investigated. According to our observations, we would say that death of all organs has taken place when no potential differences between them and any other part of the body can be determined. This point is not reached until several hours after the animal has stopped breathing. A large series of our records illustrates this fact.

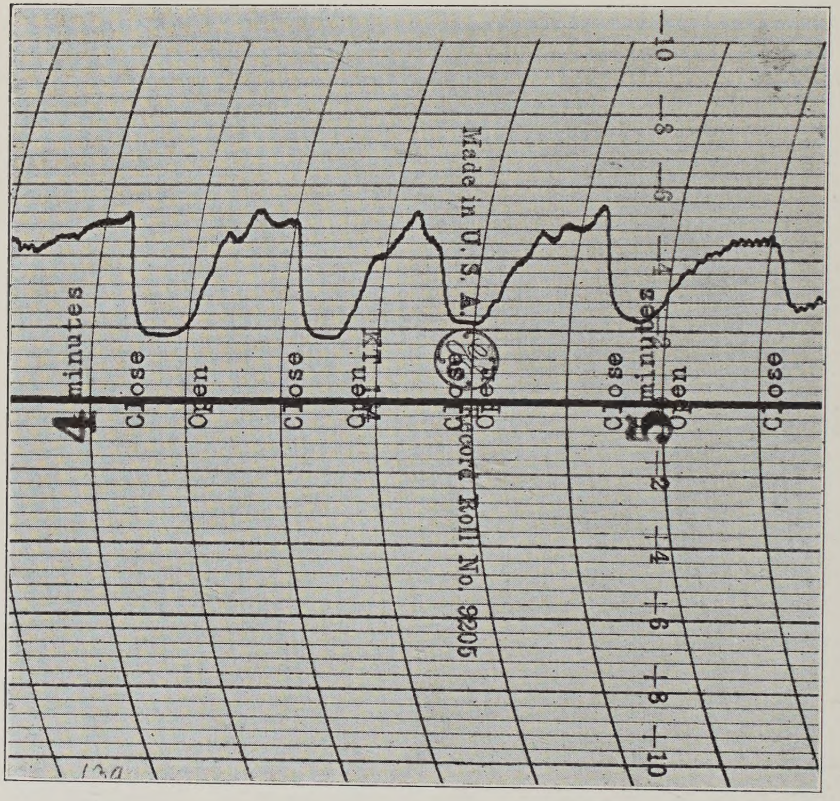


Fig. 4. Effects produced upon potential gradient by clamping and releasing aorta. Interval of time, 10 seconds.

Figure 2 illustrates the drop in the potential gradient after the animal has stopped breathing. In this case the rabbit stopped breathing shortly after the electrodes were inserted in the left ventricle and eye. During the next 7 minutes a definite decrease in the potential difference was noted and, superimposed upon the potential gradient curve, the number and amplitudes

of the heart beats were observed. During the seventh minute, 2 cc. of strychnine, 1:10, was injected directly into the heart, which then stopped beating after one minute.

Figure 3 illustrates a death curve following injection of 2 cc. of chloroform into the heart.

A definite change in potential gradients can be produced by stopping the flow of blood for short intervals. This was done by manipulation of a clamp which was fastened around the aorta

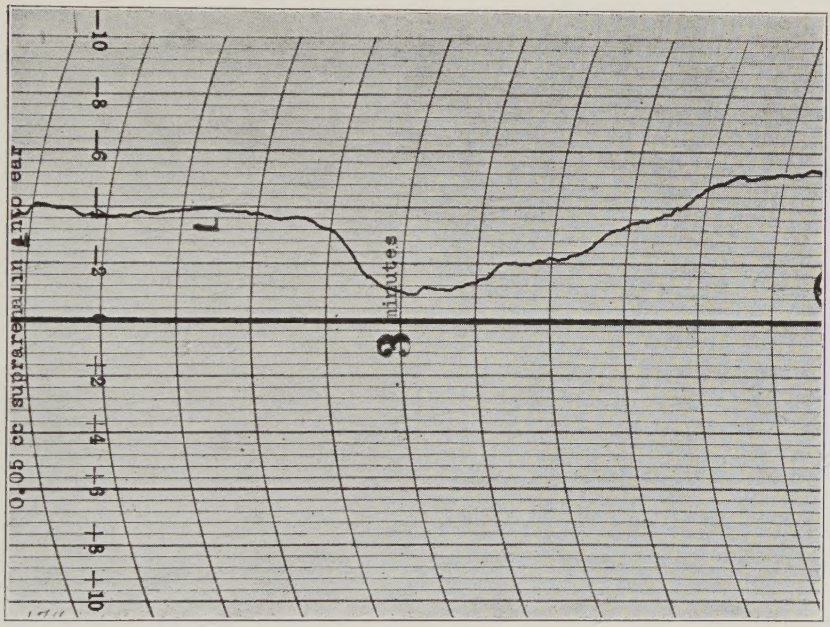


Fig. 5. Effects of adrenalin injected into adrenalectomized rabbit upon potential gradient. Interval of time, 10 seconds.

at its emergence from the heart and which permitted us to stop or start the flow of blood to the heart at will. Figure 4 illustrates the results obtained in one such experiment. Electrodes were inserted into the eye and the left ventricle of a rabbit. In the third minute the blood flow was stopped by closing the clamp, and a definite decrease in the potential difference of over 50 per cent was observed. Upon opening the clamp, the potential returned to the original value. This procedure was repeated eight times during the next two minutes, always with the same result. From the eleventh to the fifteenth minute the same

experiment was repeated about ten times with the same results. The time of stopping the blood flow in each single experiment was approximately 5 seconds. The superimposed heart beats permit the conclusion that the number of beats per minute did not change during the clamping of the aorta.

Figure 5 shows the effect of 0.05 cc. suprarenalin injected into the ear at two minute intervals upon an adrenalectomized rabbit. An initial decrease of the potential gradient about a minute after injection was observed in all cases. This was fol-

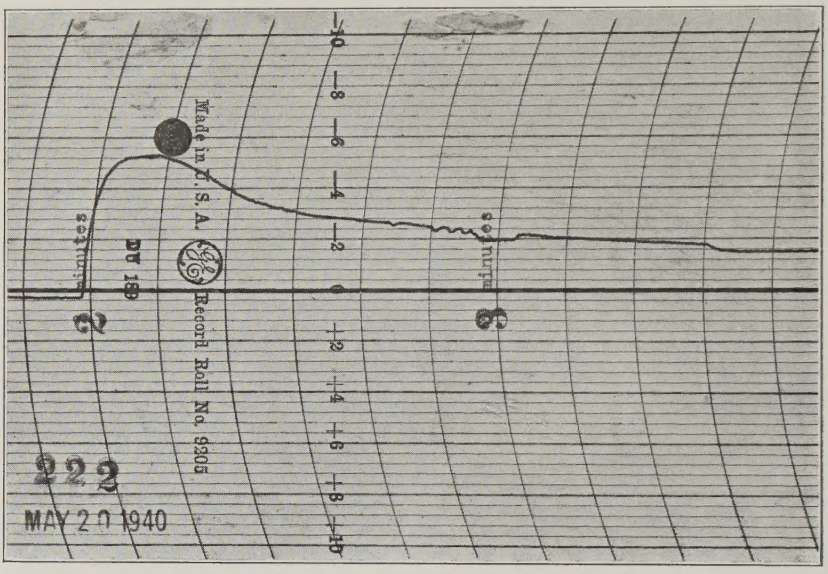


Fig. 6. Effect of pithing upon potential gradient. Rapid drop of potential difference. Interval of time, 10 seconds.

lowed by a rapid increase which carried the potential well beyond the initial value. Repeated doses after the first few injections yielded but a small effect upon the potential gradient.

Adrenalectomized rabbits were chosen for these experiments rather than the normal because only a slight increase in potential occurred in the normal animal. Presumably this is due to the fact that the normal secretion from the adrenal glands in an unoperated animal is sufficiently high to obscure the effects of added adrenalin doses from without upon the potential gradient. It is only after the adrenal glands of a normal rabbit have been

removed that this effect can be observed. Electrical stimulation directly to the adrenal glands of a normal rabbit does, however, produce a marked increase in the potential gradient. It becomes apparent that there are still a number of unknown factors with reference to the adrenalin secretion in the body as well as with reference to the effects of adrenalin introduced from without. It appears that the normally functioning body maintains a definite adrenalin balance which is difficult to disturb. However, if the balance is upset by injury or experimental interference, marked variations in the potential gradients can be observed even after addition of small amounts of adrenalin.

Narcotic agents like cocaine and morphine in small doses produce relatively small effects upon the potential gradients.

If, however, larger doses of the order of ½ mg. of cocaine were introduced into the ear, rapid fall in potential ending in convulsions and death was observed. Caffeine injected into the ear in small doses (10 mg. in 1 cc. of water) produced considerable increase in the potential gradient and subsequently showed effects in maintaining the potential level similar to that observed with cocaine.

In order to determine whether or not potential gradients could be maintained in the absence of direct nervous connection between the brain and the heart, a number of experiments were carried on in which the animal was pithed and in which the vagus and sympathetic nerves leading to the heart were severed. Figure 6 shows the result of one of these experiments upon the potential gradient measured between the eye and the left ventricle. The animal was pithed and the nerve connections severed after the normal gradient was established, and within one minute the potential difference was decreased to one half. Then it established and maintained itself at this level for at least 10 minutes.

In addition to the experiments involving potential gradients between the heart and the brain as represented by the retina of the eye, a large series of observations, as already indicated, upon the gradients of other organs with reference to the brain was made. The results have not been included in the above discussion. It is sufficient to state, however, that the liver, kidney, adrenal glands, bladder, muscle, rectum, colon, ileocolic junction, stomach, duodenum and spleen all showed a negative polarity in reference to the brain with the exception of the stomach.

Our experiments show that the polarity of the blood in the left ventricle of the heart is negative as compared with that of the brain, and furthermore that changes in the agitation of the blood within the heart are accompanied by corresponding changes in the potential gradient. A number of excitatory as well as narcotizing agents were employed to produce such changes. Other methods of interference with the flow of blood, such as momentary stoppage by mechanical means, were followed by a considerable fall in the electrical potential gradient.

It may be concluded from our experiments that the heart beat plays a definite role in the production and maintenance of the potential difference between heart and brain. Specific changes in these potential gradients may be produced by various mechanical, electrical and chemical means at will.

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**Research and Statistical Methods**

This *Yearbook*, like its predecessor, *Research and Statistical Methodology Books and Reviews* of 1933–1938, will be found especially useful both by the teacher of statistical methods and by the investigator who desires expert advice upon the wise choice of books which best suit his purposes, and who also wants suggestions for expanding his own acquaintance with newer research methods as they appear. Among the 359 book titles listed, every major field of scientific investigation is represented, usually by several books. During the period covered by this yearbook—two-thirds of the books were published in 1938–1941—Business and Economics are represented by 73 titles, Education and Psychology by 44, Biology by 28, and Mathematical Statistics by 18. Slightly less than half of these are textbooks suitable for class-room use. The other titles are concerned with fundamental problems of methodology common to all fields, or with expositions of methods for particular subfields. In all, 1,652 reviews of English language books on methodology gathered from 283 journals have been expertly excerpted for evaluative criticisms and arranged for easy reference. Indices of titles, names, and subjects, and of periodicals and publishers are appended.

The editor indicates in the preface that the service may be expanded, provided this edition proves sufficiently useful, by including titles and reviews of foreign language books, and by abstracts and critical reviews of periodical literature on research methods. It is to be hoped that succeeding *Yearbooks* may be assembled annually as long as the publishing activity in the field of research and statistical methodology continues at a high rate.—*E. L. Green.*

**The Second Yearbook of Research and Statistical Methodology Books and Reviews.** Edited by Oscar Krisen Buros. xx+383 pp. Highland Park, N. J.: The Gryphon Press, 1941. $5.00.

# INEXPENSIVE EQUIPMENT FOR THE PREPARATION AND CONCENTRATION OF PURE $D_2O$ OR OF DEUTERIUM-RICH WATER. DESCRIPTION OF CONSTRUCTION AND OPERATION OF THE FORMER OHIO STATE UNIVERSITY HEAVY WATER PLANT[1]

HERRICK L. JOHNSTON and W. HEINLEN HALL[2]
The Ohio State University

During the spring and summer of 1934 we operated, at the Ohio State University, a "heavy water" plant with a capacity for reducing about 100 gallons of water per week. In a period of sixteen weeks about 800 grams of $D_2O$ were produced, in pure or concentrated form, from about 1800 gallons of commercial electrolyte taken from the electrolytic hydrogen cells of the Capital City Products Co. of Columbus.[3]

Although this was one of the largest, and most economical, of the early plants for producing $D_2O$ we have never, heretofore, described it in any detail.[4] A number of features, and observations, warrant some description, for the benefit that they may be to those who have occasion to prepare or concentrate heavy water for research, demonstration or advanced student laboratory use.

While our plant was similar, in the main, to others that have been described (1) it possessed especial simplicity and economy in construction.

*General Plan of Operation*

The plant was designed to operate in three main stages. The first stage reduced the initial electrolyte to about 1/32 of its initial volume and, in so doing, built up the atomic concentration of deuterium in the hydrogen of the electrolyte from its initial value of about 0.05 of 1% (2) which is about three times the deuterium concentration in normal water (3) to a value of about 0.6 of 1%. This stage was divided into five steps, in each of which the electrolyte was reduced to about half volume.

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[1]Contribution from the Chemical Laboratory of The Ohio State University.

[2]Now located at Bowling Green State University.

[3]The water from this electrolyte was furnished to us, free of charge, by The Capital City Products Co. About 1400 gallons of distilled water was obtained from the 1600 gallons of electrolyte by distillation from an iron boiler and was made 0.5 N in NaOH for introduction into the first stage of our electrolytic heavy water plant. The residual concentrate from the boiler was diluted with fresh distilled water and returned to the cells of The Capital City Products Co. The distillations were carried out by students in the Chemical Engineering Department under the direction of Professor J. H. Withrow, Chairman of the Department, and Dr. J. A. Koffolt, in active charge of the distillation.

[4]Photographs of sections of the plant, and a brief description, were published in the Ohio Journal of Science 35, 362 (1935).

About 1000 water-coolled cells of an inexpensive type (types (a) and (b) of Figure 2) were used in this stage.

Between the first and second stages the concentration of alkali in the electrolyte was reduced, by neutralizing the bulk of the solution with $CO_2$. To accomplish this about 5% of the concentrated solution was set aside, to form the necessary concentration of NaOH for the next stage, and the remainder was neutralized by adding to it pieces of dry ice, in an open five gallon oil can from which the top had been cut away. The water was then distilled away from the bicarbonate solution, in a copper steam can, and added to the 5% of concentrate to form dilute electrolyte ready for the next stage.

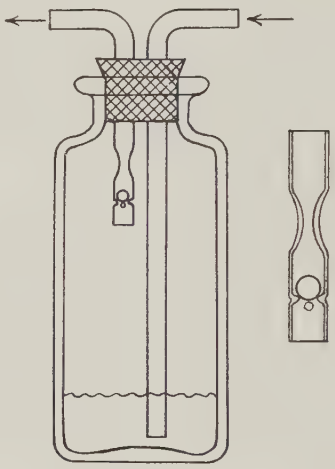

FIGURE 1

The use of solid, rather than gaseous, carbon dioxide appears to have been new with us and possesses the advantages of: (1) economy, (2) rapidity and convenience and (3) partial compensation for the heat evolved in the neutralization reaction by the heat absorbed in the sublimation. It should be noted that the $CO_2$ neutralization accomplishes normalization (or near normalization) of the oxygen isotope ratio (2), which is changed in the process of electrolysis (3). It may be that the effect of $CO_2$ from dry ice differs slightly in this respect from that customarily found for $CO_2$ from tanks, but this depends on the source of the original $CO_2$ and its method processing.

For the second stage eight tall, water jacketed cells (type f in Figure 2) were employed, in which the electrolyte could be safely reduced to about 1/5 volume in a single step. This was repeated for a second step, after which neutralization by dry ice was carried out in the manner described above. The deuterium concentration at this point in the process was between 6% and 10%.

The third stage was carried out in varying numbers of small cells (type e of Figure 2. We used a maximum of 24) which were constructed

out of eight inch Pyrex test tubes. The number of steps and the volume ratio reductions were determined by the desired purity, and the needs of the moment. In the preparation of pure heavy water at least one reduction in alkali concentration was necessary. This was usually effected by distillation of the strong NaOH solution from a Pyrex distilling flask, without neutralization.

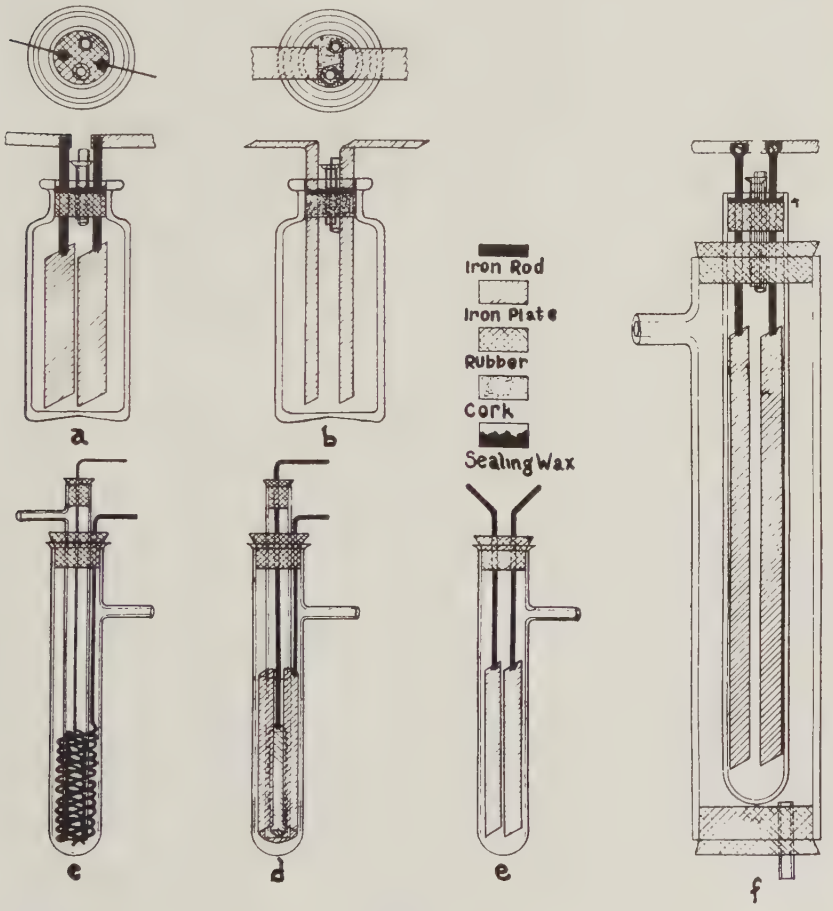


FIGURE 2

Closed cells were used in all steps of operation. In the first four steps this was for the purpose of conducting away the large volume of hydrogen (with oxygen) liberated in the electrolysis.[5] The cells were

[5]For small laboratory operations closed cells for these early steps can be dispensed with if the cell troughs are placed under a hood or in a location where they receive good ventilation. For this purpose open wide-mouthed bottles connected by U shaped electrodes, and set in troughs of running water may be employed.

grouped in banks of 50 each connected through a gas manifold and each of the banks connected to a main steel pipe manifold which terminated in a vertical pipe that projected above the roof of the building. The steel pipe was grounded to carry off static charge produced by the flow of gas. Each of the 50 cell banks was protected against possible explosions in the main manifold or in other banks by a glass bead explosion trap (Figure 1), in series with a spray trap, at the point at which it made connection with the steel pipe manifold. These functioned properly in the few cases in which explosions occurred in 50 cell units, due to eating off of anodes (cf seq).

In the fourth step of electrolysis (Stage I) the average deuterium concentration of the hydrogen which escaped from the cells was about equal to that in the initial first step electrolyte. In the fifth step the escaping hydrogen had a deuterium enrichment about intermediate between that of the electrolyte at the beginning of steps 1 and 2 respectively. This hydrogen was recovered by recombination of the oxy-hydrogen mixture (cf infra) and returned to the first step. The electrolytic gases from all steps of the second and third stages were likewise recombined and returned to the appropriate position in the plant.

*Inexpensive Forms of Closed Electrolytic Cells*

Figure 2 illustrates several types of inexpensive closed cells which we built and operated. Any of these may be constructed out of materials usually on hand in a chemical storeroom.

Types (a) and (b) use 500 cc. wide mouthed glass bottles. Type (a) is made by welding short flat electrodes to 3/16″ iron rods which project through two of the four holes drilled[6] in tight fitting rubber stoppers. The other two holes carry: (a), the gas delivery tube which may be of either glass or metal and (b), a glass or metal tube for filling and emptying the cells—(the latter by siphon). The second tube should be of such a size that it can be closed with a small cork. The wetted rubber stopper, with electrodes and tubes in place is forced to a position a little below the top of the bottle neck and covered with ceiling wax. Electrical connections are made either by drilling the projecting ends of the iron rods to take small bolts with which to bolt on narrow connecting strips of sheet copper,[7] or by using battery clips. In the type (b) cells the flat electrodes project through a tight-fitting cork which is cut into three sections by two parallel cuts. The sections of cork were soaked in hot paraffin and the assembled unit covered with sealing wax. U shaped electrodes, used in common by adjacent cells, serve also for connectors. This type of cell is satisfactory for about a month of use but eventually the alkali disintegrates the cork, which then has to be replaced. We

[6]It is best to drill these with high speed wood drills lubricated with water. The rubber stopper should be inserted in a hole drilled in a board, during the drilling operation.

[7]In drilling the rods much time is saved if a small flat surface is first ground on one side of the rod, or a thin cut taken with a milling machine, to prevent the drill from slipping. The drill holes should be parallel to the surface of the electrodes so that connectors will not require bending.

originally used (b) type cells on the first stage, but subsequently replaced them all with (a) type cells.

Both (a) and (b) cells were set in troughs of running water. They operate best at 5 to 7 amperes, which requires a littel over 4 volts per cell with 0.5 N alkali and results in an approximate 10° temperature head between electrolyte and cooling water. It is not advisable to allow the electrolyte in these cells to drop much below 200 cc. volume as, otherwise, the cells may heat up excessively. We customarily began the first step of electrolysis with 400 cc. of electrolyte and, when this volume was reduced to 200 cc, doubled up the cell contents into one-half of the original cells in preparation for the second step. The same procedure was followed after the second, third and fourth steps.

The construction of type (f) cells is clear from the diagram. The cell compartment is made from Pyrex tubing about 35 mm. in diameter. This cell offers a large cooling surface and operates well at 15 to 20 amperes. The electrolyte can safely be reduced to 1/10 volume in a single step in these cells, if desired.

Type (e) cells were used in the steps of the third and final stage. The thick iron wires that carry the electrodes are forced through small drill holes in the solid rubber stopper. The stopper with the electrodes is removed from the cell when electrolyte is added or removed and wired tightly in place when the cell is in service. This cell is set in an open wide-mouthed bottle through which cooling water circulates. The cell will carry 5 to 6 amperes without difficulty.

The above-mentioned cells permitted the electrolytic oxygen and hydrogen to mix. When, for any reason, we desired to keep them separate, we used cells of type (c) or (d) (a narrow gas outlet for the inner glass tube in (d) similar to that shown in (c) was inadvertently left off the diagram). While (c) is very easily constructed the use of cylindrically bent sheet metal, as in (d), is to be preferred because of much lower resistance offered to the current.

*Electrodes and Separation Efficiency*

Except for four hundred type (b) cells with nickel electrodes, that were subsequently replaced, electrodes for all of the cells were made of No. 20 gauge, unsurfaced Armco iron. This possesses a distinct advantage over nickel and other practical metals for efficient isotope separation. With NaOH electrolyte we obtained, with Armco iron, an electrolytic separation factor[8] of a little more than 8, whose magnitude was practically independent of current density and of the deuterium concentration in the electrolyte. This is the true separation factor applicable to the dry gas. The *practical* separation factor is somewhat less than this (about 6 or 7) due to water vapor carried out with the electrolytic gases.

[8] $\alpha$ is most simply defined as the instantaneous ratio of (H/D) in the gas to (H/D) in the water. Thus, if a 10% $D_2O$ solution (H/D = 9) is being electrolyzed and the evolving hydrogen proves to be just 2% in D (H/D = 49) the separation factor is 5.55. For low concentrations of D this resolves into the ratio of % D in the $H_2$ to % D in the $H_2O$. Thus, in the above example, 10/2 = 5.0 is nearly the correct value for $\alpha$.

This factor of 8 compares with one of only 5 for nickel and makes a considerable difference in the efficiency of separation. For example, we found that when we used iron electrodes the deuterium concentration went up by a factor of about 3 for each fourfold reduction in volume. In the sixteen fold volume reduction, during which we allowed the electrolytic gases to escape, the deuterium concentration went up by a factor of 9. With nickel as electrodes the deuterium concentration goes up by a factor of only about 4. Iron electrodes, therefore, more than double the yield of $D_2O$ as against nickel for the plan of operation which we followed.

It is obviously not practical to recombine and reclaim the electrolytic gases from the first and second steps of electrolysis, with iron electrodes, since their deuterium concentration is below that of ordinary water. Recombination in the third step is likewise impractical since the deuterium concentration is only slightly in excess of normal water. Recombination in the fourth step is about the equivalent of a 5% increase in the amount of starting material. The rather considerable amount of gas that would needs be handled to effect this economy makes recovery at this step impractical also. 7/16 of the deuterium present in the starting material is thus lost before, the recovery by recombination and repeated electrolysis becomes practical. Allowance for rejection of gas in the re-electrolysis of the water recovered in stages where recombination is practical brings this theoretical loss to a full 50%. Our 800 gram $D_2O$ production from 1400 gallons of a starting material that held a little more than 2 Kg of $D_2O$ initially is thus a reasonably good yield, and is superior to the yields reported by other plants (1). We experienced small accidental losses in handling. There were evaporation losses during the $CO_2$ neutralizations, and some electrolyte was lost, early in the operation, by explosions that resulted from corroded-off electrodes.

*Recombination of Electrolytic Gases*

Recombination of the stoichiometric oxy-hydrogen mixtures was brought about by combustion in a flame formed at the tip of a Pyrex capillary (4). The flame was prevented from firing back through the capillary by the high velocity of gas flow under a small pressure head developed in the cells. The choice of diameter for the capillary was determined by the rate at which the gas was generated—i. e., by the number of cells delivering gas to the burners and by the current.

We obtained best performance with tips made by fusing a four or five millimeter length of Pyrex capillary to a two or three inch length of wider tubing. We have used tips constructed in this manner for three or four weeks of nearly continuous service without need of replacement. With tips of this description, and the proper choice of capillary diameter, we have obtained satisfactory results in the wide range of gas flow that lies between the delivery from a single cell operating on 6 amperes and that of 50 cells operating at 12 amperes. For the latter the flame was over a foot long.

The oxy-hydrogen flames were directed into water-cooled Pyrex tubes that served as condensers. Tubes were chosen of such diameter as to provide at least a quarter-inch clearance around the flame. With

very large flames cylinders of copper gauze were inserted in the condensers to protect the glass.

Explosion traps to protect the cells from "backfires" in the combustion train when the gas flow would be reduced were formed from 100 cc. Pyrex round-bottom flasks tubulated at the bottom and filled with fine river sand.[9] These traps proved 100% effective in hundreds of trials with various rates of gas flow.

The burners were allowed to operate over night, without attention, except for stage 3 electrolyses. Because of the value of the water at this stage the electrolyses were given personal attention.

*Foaming*

Not infrequently, foaming occurred during the first half hour of electrolysis in the first stage and in stages that followed neutralization. The nature of all the impurities responsible for this were not determined but it was found that cork in the electrolyte was a particularly bad foam producer.

The impurities responsible are adsorbed in the surface and carried over with the foam. Addition of a few lumps of calcium chloride to the salvaged spray, followed by distillation, proved effective in correcting this condition. Addition of a small amount of permanganate as well as $CaCl_2$ and distillation nearly to dryness so that chlorine[10] is liberated, is helpful in extreme cases.

*Corrosion of Electrodes*

During nearly continuous operation of 1000 cells for a period of four months two or three dozen examples of severe corrosion were observed. The comparative infrequency of this trouble made the isolation of its causes, and hence its prevention, the more difficult. The peculiar thing is that an electrode which has been in service many weeks with little or no indication of corrosion may suddenly develop this condition and rust entirely off at the electrolyte surface within a period of six or eight hours. Other cells connected in series with the faulty cell and apparently subjected to the same operating conditions will escape corrosion altogether.

Corrosion is no more frequent with iron than with nickel electrodes. However, the advanced stages of corrosion develop more slowly with nickel on account of the more impervious character of the black oxide coating. For this reason iron offers a somewhat greater hazard in the operation of closed cells through danger of sparks between the electrolyte and an eaten off anode.

Overheated cells are more apt to develop this condition than cells which operate at lower temperatures. Electrolyte removed from a cell in which corrosion has started very frequently (but not invariably)

[9] 60% of this sand passed through a sieve with 50 meshes to the inch. A sample of pure silica whose grains were of approximately 35 mesh size failed to stop explosions, in similar tests.

[10] All traces of chlorine or of chloride ion must be removed from the distillate before return to the cells. Otherwise corrosion results.

produces this condition in other cells to which it is added. The *distillate* from a contaminated batch of electrolyte is non-corrosive, however. Electrolyte prepared from tap water, or contaminated with tap water, increases the chance of corrosion. The presence of a trace of $CaCl_2$ which reached the distillate during distillation of a foamy batch of electrolyte produced immediate and excessive corrosion in every cell to which this distillate was added. From the latter two observations and the fact that the anode is the electrode which is attacked we conclude that chloride ion, even in traces, is the promoter of corrosion.

The only dependable protection against losses through this hazard lies in frequent inspection. For cells in which the visibility is limited current drop in the circuit containing a faulty cell and excessive heating in the cell itself are reliable criteria. The cell resistance is so increased by corrosion that even in a circuit with twenty-five cells in series corrosion in a single cell results in a 20% to 25% drop in current several hours in advance of actual rusting off.

*The Deposit of Alkali Metal*

In a few instances we permitted electrolysis to continue until a saturated solution of the alkali hydroxide was formed. This resulted, in one such instance, in an explosion in one of the cells a few minutes after electrolysis was stopped. The cause of the explosion was definitely traced to the presence of free alkali metal which had deposited, under a layer of the solid hydroxide, at the cathode surface. Free alkali metal deposits from aqueous solution, under these conditions, in such quantity that it can be scaled from the electrode and easily identified.

*Acknowledgments*

We gratefully acknowledge the generosity and helpful co-operation of the Capital City Products Co. of Columbus, who furnished the deuterium-enriched water for this program. We are also grateful to Professor J. H. Withrow and Dr. J. A. Koffolt and their students in Chemical Engineering for their recovery of the potash in the original 1600 gallons of electrolyte. We wish to acknowledge the co-operation of the directors of the Ohio Engineering Experiment Station and of Mr. William McCracken, former university engineer, who made building, generator and electric power facilities available to us. Finally, we wish to thank Dr. C. O. Davis who assisted us in the analysis of the electrolyte and in preliminary experiments with the design and operation of cells.

## SUMMARY

The plan of operation of the former "heavy water" plant at The Ohio State University is outlined and several forms of inexpensive closed cells are described.

The advantage of iron electrodes over those of nickel, in plants for the concentration of deuterium, is pointed out and figures given as to the efficiency of deuterium production.

The construction of a durable burner tip for the combustion of the electrolytic gas in the advanced stages of electrolysis is described.

The advantages of solid carbon dioxide as an agent for neutralizing alkaline solutions, in deuterium recovery, are pointed out.

Experience in combatting foam and experiences with corrosion of iron and nickel electrodes and with the deposit of free sodium from concentrated NaOH are described.

## LITERATURE CITED

(1) **G. N. Lewis** and **R. T. MacDonald,** J. Chem. Phys. 1,341 (1933); **H. S. Taylor, H. Eyring** and **A. A. Frost,** ibid 1,823 (1933); **F. C. Anderson, Ja. A. Halford** and **J. R. Bates,** ibid 2,342 (1934); **W. G. Brown** and **A. F. Daggett,** ibid 3,216 (1935).
(2) **W. H. Hall** and **H. L. Johnston,** J. Am. Chem. Soc. 57 1515 (1935).
(3) **H. L. Johnston,** J. Am. Chem. Soc. 57,484 (1935).
(4) **H. S. Taylor, H. Eyring** and **A. A. Frost,** J. Chem. Physics 1,823 (1933).

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### Microscopic Anatomy of the Vertebrates

Dr. Kendall's recent revision of "The Microscopic Anatomy of the Vertebrates," of which he was originally coauthor with Professor Scott, offers a different arrangement and method of presentation which should fit well into beginning courses in histology as they are offered in many Arts College curricula. The author has adhered to the policy of keeping the book small, but it appears that in some instances even the descriptive material is exceedingly abridged. Kendall purposely has avoided the pitfalls of attempting to correlate structure with function. Although that may be dangerous ground on which to tread, it appears that an understanding of modern histology is incomplete without some acquaintance with at least the better established histochemical and histophysiological interpretations commonly accepted by the students of microscopic anatomy.

The book is unique in that the histology and organology of many organs is presented as it appears in each of three or more classes of vertebrates. In this respect the text approaches the requirements of many instructors who offer courses in Comparative Vertebrate Histology. Since this was not the author's objective no word of criticism is voiced but it would be most gratifying to many of us to see a truly comparative histology appear on the booklists. At the present time I believe Kendall's revision is the best approach to a concise treatment in comparative histology even though it was not so designed. The author has made many improvements in the figures, but certain areas are still woefully deficient in the quality of the photographs. The passages on the kidney and endocrines are especially weak in illustrative material. The book would be greatly improved by enlarging all illustrations to bring into relief much detail so important to students of histology.

The reviewer is fully aware of the difficulties confronted by the author in attempting to assemble comparable photographs of good quality to meet the objectives of the text. The literature is vast and scattered and contains a dearth of excellent photographs which would be appropriate for use here. The author is faced with the problem of obtaining tissues from a wide variety of animals, making preparations, and finally solving photomicrographic problems. It is therefore with a feeling of constructive criticism that these suggestions are made.

—*Clinton M. Osborn.*

**Microscopic Anatomy of Vertebrates,** by James I. Kendall. 342 pp. Philadelphia, Lea and Febiger, 1940.

# THE GEOGRAPHY OF THE BELLEVUE AREA

RUTH ROCKWOOD DAUGHERTY

## INTRODUCTION

Bellevue, Ohio, is located on the north-south boundary line between the counties of Huron and Sandusky near the middle of the state east and west and twelve miles south of Sandusky Bay.

Bellevue lies on a poorly defined, sand dune covered section of Maumee Beach on the southern border of the Lake Plain. The sink hole topography in the neighborhood has given this town unusual drainage and water problems. The site was chosen for white settlement about one hundred and twenty-five years ago. From the rural simplicity of the pioneer day the present landscapes, including the culture, have unfolded gradually, stimulated by the development of the railroads, and by the limestone industry.

In the following chapters the natural environment is first described, then the pattern and functions of the landscapes before the railroad period, and finally the modern landscape influenced by the railroads.

## PHYSICAL CHARACTERISTICS

### TOPOGRAPHY

To the north of Bellevue extends the pro-glacial Lake Plain which runs roughly parallel to the southern shore of Lake Erie. This Plain is wider to the west, is broken into strips one and a half to five miles wide by the Whittlesey and Warren beaches, and attains an average total width of about twelve miles. Bellevue is on the southernmost of the three beach ridges, the Maumee, which forms the dividing line between the Lake Plain and the Till Plain. Sand dunes and sink holes have considerably modified the beach topography. The crest of the beach is ill-defined at Bellevue because it has suffered a long period of wind and water erosion. The central part of the town is on the gently northward sloping Lake Maumee plain. The northern edge of the beach, shaped roughly like a horse-shoe, enters the town limits at the northwest corner, swings to the south in a poorly defined line, and leaves the town boundary at the northeast corner. Its crest is broken on the west and south side of the town because of the numerous sand dunes, and on the eastern side intermittent and artificial stream work has etched into the beach. The altitudes of the three beaches are about 780′, 740′, and 680′ above sea-level. They stand from 20′ to 30′ above the bordering Lake Plain and perceptibly above the Till Plain on its border though it rises south.

Their northern slopes, although steeper than their southern slopes, are still gentler than those farther east.

The beaches at this end of the Lake Plain do not stand out as conspicuously above the plain as they do toward Cleveland. They are generally better drained than the Lake Plain because of their elevation and their porous soils.

*The Lake Plain*—About one-half of the town of Bellevue lies on the Maumee Lake Plain, approximately 745′ high in Bellevue. Sink holes and a few sand dunes modify the topography. This plain rises toward the south approximately 17′ in a mile, steeper toward the Maumee beach and gentler toward the Whittlesey.

The Lake Plain in and west of Bellevue has an undulating surface due to the sand dunes and sink holes. Several areas among these features are poorly drained, even swampy, and spring rains cause water to stand for several days. Because of sinks and sub-surface drainage, streams are few, intermittent, and follow poorly developed valleys. One such valley, about 15′ deep, on the eastern side of the town has been dredged. Most of the drainage is thus dependent upon the sink holes and porosity of the mantle rock, which are not sufficient during heavy rains.

*Glacial Plain*—The southernmost part of this town, south of Maumee beach, is on the level Till Plain. Feeble and intermittent streams also help to drain this plain. In the southeast corner of this town is a glacial kettle whose rim has been strengthened by man. This pond, called the Old Mill Pond, broke through its banks during the flood of 1936. They were hurriedly rebuilt and the pond left undrained although it now serves no particular use.

The sink holes[1] within this area are both natural and artificial. Eighteen or more natural sink holes occur within the town, each usually in a depression varying from 5′ to 15′ in depth and made by washing earth down the hole. These sometimes fill up with surface wash which has to be sucked or dug out to restore the drainage. About seven more are found in town on the Lake Plain and they continue northward as far as Castalia.

*A Geological Section*—The beach sands, the gravels of the ridges, and the stratified and thickly bedded lake clays of the Lake Plain form the mantle rock north and a varying layer of drift mantles all south. Glacial drift, which varies in thickness from 18′ to about 80′, underlies the lake sediments.

The Columbus limestone and the Lucas dolomite of the Devonian system form the bedrock for this region. Both are strong rock, and though shattered and disturbed some by solution slumping, are the basis for a valuable industry (6). The quarry is opened to a depth of approximately 45′. Beneath these Devonian rocks other limestones are known but no values have ever been discovered in them near Bellevue.

Caves and underground passages in this limestone are frequent. Some of the small caves in the region bordering the town have been filled in. Drillings for artificial sink holes vary from 32′ to 248′, where they reach crevices in the limestone that carry away water and waste.

[1]Hubbard, G. D., shown on a map of sink holes drawn in 1913.

## CLIMATE

Bellevue is in the Temperate Zone of cyclonic storms, and is on the borderline between Koppen's *cfa* and *cfo* types of climate; that is, a constantly moist climate with at least one month having a mean temperature of 64.4° F. May, June, and July have an average mean rainfall of over three inches per month, and all others over two inches. Thus during the growing season over half the annual amount of rain falls.

The three warmest months are June, July, and August. The combination of rain and high temperature assures a good growing season. Decreasing rainfall in August and fore part of September and the high temperature permit a successful harvest season in the adjoining farming regions.

Because of the proximity of Lake Erie, Bellevue and the adjoining regions have a longer growing season than is ordinarily expected. Lake Erie retards the spring and fall. The last average killing frost in the fall is between October 10 and 15. Thus the length of the growing season, 192 to 198 days, combined with the slow cooling in the fall and the slow rise of temperature in the spring encourages the growth of fruit crops such as cherries, peaches, and apples, and near the lake, grapes, which in turn influences the industries of this town.

## THE ABORIGINAL FOREST COVER

The early settlers who came to the site of this town called the area immediately to the west the "Oak Openings," where the larger forest trees were really "few and far between" and mostly white oak and hickory. The undergrowth consisted of small hickory, scrub oak, sassafras, spice, hazel, huckleberry, and alder. In the rest of Sandusky County the forests were generally made up of "white, black, red, scarlet, bur and pin oak, white and red (slippery) elm, white, black and blue ash, common and big shellbark hickory, smooth hickory, white and yellow poplar, cottonwood, linden (basswood), sugar maple, beech, black and white walnut, soft maple, buckeye, sycamore, hackberry, honey locust, willow, and iron wood," with only a little difference between the stock of higher and of lower, wetter land (5). Chestnut was found in few places, usually on the beaches. Maumee beach was called "Butternut Ridge" by the settlers because of its numerous butternut trees. This region is a transition between the Southern Hardwood (oak-hickory forest), and the Southern Chestnut (chestnut, oak, yellow poplar forest). The climate was warm enough to permit both types and the sandy soils favored the latter. The amount and distribution of the rainfall with the maximum in the summer and the long growing season explain the large size of some of the forest trees.

The area immediately to the east was called the "Prairies." This was formerly a part of the Maumee Lake Bed. The surface is remarkably level and underlain with a very fine soil. Consequently, this area is alternately too wet and too dry for the growth of trees except where locally a more porous soil prevails. As a result few trees grew, and prairies prevailed.

Many early settlers upon entering the "Prairies" and the "Oak Openings" judged that the soil was not fertile enough to produce crops because it did not produce many trees and so passed on to more heavily timbered country, expressing their regret after their mistake had been proven.

## EARLY HUMAN OCCUPANCE

*Landscape During the Indian Period*—The area around Bellevue was occupied for an indefinitely long time before the appearance of white men. Burial mounds are found at various places in Sandusky County, usually along streams and beaches. One such mound was opened a few years ago by museum authorities within one-half mile of the west town corporation line. Because of the character of the remains in the mound and the imperfect construction of the earthworks scientists claim they belong to the Eries who were exterminated in the early 16th century by the Iroquois. These lands remained little more than hunting grounds for half a century or more until the Wyandots, Ottawas, and remnants of other dispersed tribes regained some power and returned. The Indians settled near the lake and streams and used the adjoining lands for hunting. Judged from the numerous arrowheads, tomahawks, and other Indian relics along the beach ridges these must have been used as trails, probably chosen because of their superior drainage.

The Indians depended on the indigenous wild life leaving the forest cover little altered. The prairies were burned over each fall because the deer were more easily tracked and hunted over the bare and blackened soil. They tilled some soil in a superficial way and often had short crops. The Indian was primarily a hunter and a tribal warrior until an overpowering enemy, the white man came. Because he exploited only the wild life of the forest and streams, which is almost non-existent today, he was semi-nomadic. He built no enduring institutions or lasting establishments. All there is left are a few earthworks or Indian mounds, arrowheads, charcoal, fish or clamshell heaps and place names adopted by the white settlers.

Although the Indian occupance of the land was only semi-permanent it retarded the settlement of white men until treaties had been consummated with the United States government. In spite of these treaties the Indians desultorily occupied this territory and reluctantly gave up their hunting grounds.

*Indian Removal and Survey Period*—The story of the gradual encroachment of the white settler upon the Indian lands was the same as usual on the American frontiers. Ceding by the Indians began in 1785 when a two mile square in Sandusky County was acquired to build Fremont. Roadways 120 feet wide and adjacent farm lands were next granted. Cession was sometimes made for cash. In 1807 Surveyor Tappan wrote that all the Indians (Wyandot, Ottawa, Chippewa, Munsee, Delaware, Shawnee, and Pottawattamie tribes) had evacuated this tract of over three and a quarter millions of acres (3,366,000 acres).

Following the Indian removal from the "Firelands" the territory was occupied for about two years only by the surveyors of the Connecticut Land Company. The western boundary of the Connecticut

Reserve was run a little west of north instead of due north so that some of the springs north of Bellevue could be included. The drawing which established the ownership of these lands took place in November, 1808. Very few, if any, of these owners ever lived upon their lands. Thus during the interim between the time of the Indian removal and the white settlement there was little or no change in the landscape.

The owners then subdivided the land and sold parcels to the individual settlers who often selected the land after they arrived. On February 12, 1820 "The New Purchase" (lands west of the Connecticut Reserve) was carved into 14 counties of which Sandusky was one.

The Indians, The Connecticut Land Company, the late survey of the lands west of the "Firelands," and the War of 1812 retarded settlement in this part of Ohio until much later than in southern Ohio. The exceptionally cold summer of 1816 with frosts in New England every month stimulated their settlement.

*Pioneer Settlement in Pre-railroad Days*—In 1815 the first settler of Bellevue, Mark Hopkins, of Genessee County, N. Y., located with his family on Maumee beach about one-fourth mile from the eastern boundary of the town. In February, 1815, John Baker, from Cortlandt County, N. Y., located about two and one-half miles northeast from the first cabin. The first settlers drove their ox teams along the trails which followed the higher and better drained beach ridges to the sites of their respective farms. Much of the surface of the Lake Plain was marshy and as a consequence the beach ridges and the sand dunes directed the pattern of settlement.

When Bellevue was on the western fringe of settlement the first settlements were in scattered isolated clearings of the wilderness. Simple cabins of the rough-hewn, abundant logs with chimneys of stone and mud, and "shake" roofs formed the homes for the first settlers. The first crops of corn and forage were often raised among the stumps of hastily cleared land. With the abundance of wood and the necessity of speedy clearing men resorted to fire as the cheapest and easiest way of preparing the land for agriculture. Log rolling, where logs were cut and stacked into great piles, and burned, were so numerous and essential that they became a part of the social life of the pioneer. Rapidly the landscape changed into the rectangular, open fields waving with grain and dotted with woodland.

Subsistence farming was necessarily the most important occupation of the period. Corn, wheat, oats, potatoes, and vegetables were planted in the cleared spaces. Sheep and cattle grazed on the swamp land and the prairies until sufficient land had been cleared of trees and underbrush.

Hunting was another important employment of the early settlers and often supplied the greater amount of their subsistence. It was customary for families to live several months on a meat diet with no bread. Furs were used instead of money.

The forests furnished materials for the pioneer's home, furniture, tools and fences. The fruits, berries, nuts, wild honey, and the maple sugar were some of the important and needed products of the forest. The burning of deciduous hardwood furnished "black salts" often concentrated into "pearlash" or potash. This ash supplemented furs

for money. With these the pioneers bought salt, rifles, iron, cotton clothing, tea, and paid their taxes. The pioneer, unlike the Indian who depended upon the gifts of nature for a livelihood, exploited the forest and the soil.

Of necessity most of the manufacturing was done in the home; clothing, farm tools, candles and furniture. Every household was more self-sufficient than any of later date. In 1823 Nathaniel and Fred Chapman established the first retail business to supply some things that could not be made. The first manufactories to come were the grist and the saw mills usually run by little water powers. These depended upon the products of forest and soil. The settlers of this streamless sink hole area had to go east to permanent streams to set up their mills. Even here water wheels were not very dependable because of the freezing in winter, the level topography, and the occasional droughts. The first mill in this area was built in Lyme Township in 1818.

Blacksmithing, an industry necessary to the farmer settler was established here as early as 1817 and another quickly followed. The smiths not only shod horses but made axes, hammers, carts, harrows, all of a plow except the mold board, and many iron articles.

There was little surplus or sale of farm products. Transportation from this region was too difficult. The ox teams which were generally used were driven along the old Indian trails following the higher beach ridges to Lower Sandusky, (now Fremont) a trading post. Few bushels of wheat and corn followed this route, until 1825 when the Erie Canal opened a world market.

Early in the history of Bellevue the farmer pioneer settlers recognized the need of taverns on this beach ridge which led to the west. The first hotel (1816) was a log cabin standing near the center of the present town. Because of the nature of the roads taverns were numerous and travelers occasionally stayed at the same tavern two nights in succession, especially during spring rains.

*Roads and Settlement*—The early roads followed the Indian trails along the better drained beaches. The Maumee and Western Reserve Turnpike, a military road 120 feet wide, was built on a grant of land to extend from the Maumee River to the western boundary of the Connecticut "Firelands." Other roads crossed and fed travelers into this turnpike.

*The Embryo Village*—In 1824 this military road which had been ceded to the state of Ohio was laid out and established on its present line, with its eastern terminus at the Strong's Ridge road. This was the starting point for Amsden's Corners named for the settler who kept the tavern. When the north and south road came here the settlement was called York Cross Roads. It grew to the present Bellevue.

The Kilbourne Road was ultimately routed through York Cross Roads and stimulated its growth. It was followed by the route to Cold Creek or Castalia.

Strong's Ridge Road was preceded in the early years by the winding Indian beach trail. Later, in order to straighten the road to its present line, artificial gradings were made. In the unplanned town the higher, better drained, and more level land had been used for roads and home sites.

*Bellevue Surveyed and Laid Out*—In 1835, fifty acres on the Huron County side was laid out in village lots of varied sizes and prices, the average being one-quarter acre for $50. In 1839 land on the Sandusky County side was surveyed and laid out. These lots were somewhat larger and in order to get settlers prices were lowered, terms were made easier, and speculators were discouraged. The town of Bellevue was incorporated January 25, 1851.

The settlers of these early days were of four different strains as shown by their names. The New York and New England influence is represented by the Woodwards, Sheffields, Bakers, and Woods; the Pennsylvania Dutch by the Kerns, Leibachs, Hetters, and Wolfslagels; the English element by the Heals, Willses, and Potters; and the German strain by the Bollenbachers, Liebers, Ruffings, and the Biebrickers. In recent years Italians and a few negroes have been brought in by the railroads as a cheap labor supply. The best property and positions are held by people of the first four strains.

## THE RAILROAD STAGES

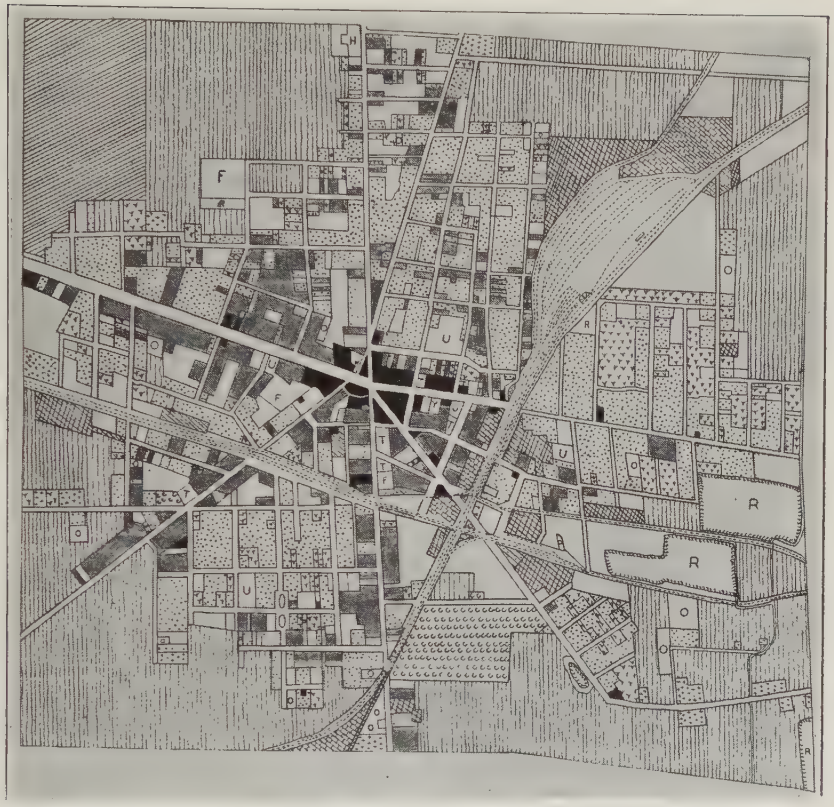
*The Coming of the Railroad*—The present history of the town is closely connected with railroad development. James H. Bell, a civil engineer of the Mad River and Lake Erie Railroad named this station Bellevue which suggested his name and his judgment of the site. This railroad was extended to Tiffin in 1841 and later to Springfield. In 1855 this route, from Sandusky to Tiffin, was changed to go by way of Green Springs and Clyde instead of Bellevue, but another railroad came soon.

In the early year the railroad was considered by most people as a great promoter of business because of the widened markets for the community through which it passed. As soon as the Toledo, Norwalk, and Cleveland Railroad was incorporated in 1852, Sandusky County voters authorized that $50,000 of its stock be purchased. The road was completed in 1853. Today it is known as the Lake Shore and Michigan Southern Division of the New York Central.

After the coming of the railroad the growth of the town was steady and continuous. Shops and business establishments were erected. Population increased so that in 1869 the corporation limits of the town were enlarged from a mile east and west along Main Street and extending one-fourth of a mile north and south of this street to a mile and a half square. The town was still equally divided between the two counties. When Bellevue was incorporated the population was about 800, in 1873 it was about 3,500. Today it is over 6,800.

## BELLEVUE TODAY

Bellevue, a compact settlement, is almost square. Because of the convergence of the main route which followed the ridge the Western Reserve Maumee Pike with the routes which come from the Lake Plain and because of the diagonal railroad routes which cross the town and intersect in it, Bellevue could be called a town of many angles. The Strong's Ridge road which followed Center Street was straightened to the present line of Main Street. This explains the awkward angle by



LAND UTILIZATION MAP
OF
BELLEVUE, OHIO
SCALE

INDUSTRIAL
MANUFACTURING
QUARRYING
AGRICULTURAL
ORCHARD
CROP
GARDEN
VACANT

RESIDENTIAL
HOUSE AND GARDEN
HOUSE
FARMSTEAD
COMMERCIAL
BUSINESS
OTHER USES
RAILROADS
STORAGE

PUBLIC
SCHOOL
CHURCH
PARKS
CEMETERY
HOSPITAL
TOWNHALL
RESERVOIR

which Center Street comes into Monroe Street. Today the Huron side of Bellevue has a majority of the people because of its early start and because it was favored by the railroads. With the exceptions of the quarry and the Bellevue Manufacturing Company, industries and their laborers following the railroads, are located on the Huron or eastern side of the town.

The residential sections of the town are generally attractive. The better homes and broader lawns are located along the main streets away from the railroad and on the higher land west of the center of town. Along the Maumee Pike the strip of lawn between the curb and sidewalk is exceptionally wide, 20 feet on each side, because of the original land grant, and because of the broad, better drained beach ridge and dune area. The predominance of small homes, narrow lots, and well kept kitchen gardens proclaim a middle class population living comfortably on modest cash incomes. Most of these yards are planted with fruit trees and vines. The dilapidated homes of the Italian population along the Nickel Plate Railroad and southeast of the center of the town are not so attractive, with tiny lawns, the narrower lots, and proportionally larger kitchen gardens. In the backyards of most of these homes may be seen a small chicken house and few rabbit hutches fitting snugly beside a family garage. The only vacant houses in town in 1939 were two in this section.

Styles in architecture are extremely varied. The older, larger homes are in an ornate style, prevalent during the 80's. Three large limestone houses, two on Southwest Street and one on the Maumee Pike, date from the 30's, and reflect the proximity and durability of the limestone. Most of the homes are small, from one to two story frame structures to which rooms have been added as occasion has required and are a response to the cheapness of land and modest incomes. But few homes are of recent construction, suggesting the extremely slow expansion of population.

About 80 per cent of the Bellevue residences have limestone foundations. Brick, tile, or cement foundations of recent buildings indicate the attachment to local, serviceable, cheap, materials. Over 90 per cent of the sidewalks are of the Berea sandstone flagging which fact attests the relative cheapness of transportation from the Amherst Quarries 40 miles away during the development of this town.

The main roads of the town are brick of local clays, while many of the side streets are of crushed limestone.

The nucleus of the retail district is in the central part of the town, the "Corners," on Main Street for about four short blocks and a few doors down each of the side streets of this section.

The buildings of the retail district are not distinctive; one to two story brick or frame structures give a low profile and emphasize the relative cheapness of land. Salesrooms are on the first floors, professional and living apartments or storage rooms on the second. The neat stone fronts of the recently built bank buildings near the center of the town add a welcome note of modernity.

The merchandizing establishments are of the usual types: groceries, meat markets, furniture, clothing, dry goods stores, auto supply shops,

hardware and dime stores, shoe repair shop, drug stores, a news stand, feed stores, and garages with sales rooms for the popular and inexpensive automobiles. Five one-room groceries, often a room in a private home located from three to six blocks from the center of town, are a convenience for the local residents. The town possesses two movie houses. One runs but three days a week because the modern means of transportation encourage competition with the cinemas in Fremont, Norwalk, and Sandusky each about 15 miles away. The hardware store, handling farm implements extends its influence into surrounding agricultural regions. A barn for the storage and display of implements is located on cheap lands near the Nickel Plate Railroad. Filling stations occupy many of the corners in the town, especially those bordering state route No. 20, where heavier traffic runs.

Much expense and effort have been given to the cultural needs of the community. There are six school buildings, five of which are grade schools and scattered throughout the town. One parochial school is situated within two blocks of the nucleus of town. The public schools in the eastern and southern parts of town are farthest from the center ($4\frac{1}{2}$ and $5\frac{1}{2}$ blocks). All school buildings are brick structures.

Eleven different Christian denominations are represented in this town: the Catholic, Lutheran, Baptist, Episcopal, Reform, Congregational, Christian Scientist, Methodist, Evangelical, Church of The Nazarene, and The Church of God. The Catholic, Lutheran, Evangelical, and Reform churches are of brick, the Episcopal Church uses the durable, attractive limestone from the Bellevue quarry. The Congregational Church is a solid Ohio sandstone structure. The Baptist Church is a frame building. An attractive but scarcely durable stucco covering has been put on the Methodist and Christian Scientist Churches. The Church of The Nazarene and The Church of God are of more recent origin and thus occupy a room in commercial blocks in the retail section. The churches, with the exception of the Reform Church, are convenient and accessible. Each is on a main street, except the Baptist Church which is a half block north of Main Street.

Recreational facilities are found at the Y. M. C. A., in a large park used for baseball and other outdoor sports out where land is cheap; the high school stadium on the low level land just south of the sand dunes along Main Street a block west of the center of town.

On the outer zones of the residential and industrial sections of Bellevue is an irregular zone of agricultural land. This illustrates the relative cheapness of land within the corporation. Fifteen farmsteads are found within the town limits. Corn, small grains, hay, and pasture are the most popular crops. A small percentage of this outer zone remains vacant and unproductive, because of sink holes and the consequent poor drainage during the rainy season.

The railroads are the most important industry of Bellevue. The Lake Shore & Michigan Southern and the Wheeling and Lake Erie divisions of the New York Central cross in an east-west direction in the southern half of town. The Pennsylvania, only a freight road, the Nickel Plate Railroad (New York, Chicago, and St. Louis division) enter the town from the northwest and continue south, and the latter

turns and leaves the town at the southwest. Their depots are within two or three blocks of the center of town. The Nickel Plate has a terminal here for one division because Bellevue is situated on the level Lake Plain on the important transportation lines between large industrial centers of the country, and because it has plenty of land to offer railroads.

Approximately 650 residents work for the railroads in shops, yards, and on train service. Because the railroads consume about half the total town supply of water much anxiety is felt during dry years, such as 1934 and 1939.

The importance of the railroads may be estimated from the large amount of land in the town utilized by this cultural feature. They have cut diagonally across the town, disturbing the streets of the town and the property lines. On East Main Street (State Route No. 20) the motor traffic was often stopped by the numerous trains. Because of the continual loss of time and the inconvenience experienced, as well as a terrific accident, at this crossing, a subway bridge was completed in 1938. The railroads go over the motor road. Work was suspended for some time during the spring of 1936 because the excavation was completely submerged. In order to keep this depression free of the surface water after an ordinary rain, a $7,000 electric pump has been installed to pump the water from the subway to adjoining sink holes.

Three mills stand beside the Lake Shore and Michigan Southern R. R. and the Wheeling and Lake Erie R. R., one at the intersection of these railroads with the Nickel Plate. Farmers of the surrounding area often sell their surplus grain at these mills and bring grain to be ground for stock food. Sometimes the mill ships this surplus grain by railroad or truck to larger markets, such as Cleveland. Lumber and coal yards are all near a railroad.

Two bakeries and four creameries are the chief subsistence industries. The dairies buy most of their milk from the farmers of the surrounding regions. Trucks collect it each day and bring it to the plants which are within the town, with one exception, where it is made ready for retailing. Each dairy does not employ more than half a dozen men.

Bellevue industrial establishments are not as much local necessities as in early days, but they are dependent on local products or market. Several are distinctly seasonal. A cherry cannery and a kraut and pickle company join with a pork packing company in the employ of 250 workers and the use of tons of sand dune cherries, beach cabbage and cucumbers, and many hogs of nearby farms. Bellevue and many of the nearby towns are supplied by means of delivery trucks with the products of these companies.

The Ohio Cultivator Company, employing about 200, meets the surrounding agricultural needs and makes use of two railroads.

Two companies manufacture iron and steel products, for a wide market, particularly through General Motors, Incorporated. All these industrial plants are near railroads and together give to Bellevue an industrial flavor and a smoky sky line or profile.

Public utilities, some of them privately owned, and the town newspaper give employment to nearly 20 people.

The France Stone Company is located at the limestone quarry on the northwestern edge of town. This quarry has been operated since early days; as a result, it is well into its second level cut and approximately 45 feet deep. About 150,000 tons of rock are quarried annually. Most of this is used for road materials for the surrounding areas. Other uses are for flux out of town, land lime on farms, and concrete blocks mostly in town. Because of the proximity of the quarry and the consequent cheaper transportation, the city is planning to use some of this stone for re-enforcing the walls of the reservoirs. Approximately 25 men are employed in this industry.

Bellevue depends upon surface water. Three large reservoirs, with combined capacity of 295,000,000 gallons, are located on the eastern side of the town. During dry years, such as 1934, this surface supply is not sufficient. A well 165 feet deep, with harder water, is then drawn upon, and the sprinkling of lawns and gardens is forbidden. In the fall of 1936 a new purifying plant was established near the middle reservoir, to insure a more healthful water. During an early period of growth the citizens of the town rejected a plan to get the town's water from Lake Erie. This vote has been regretted by many because the present water is harder than lake water with many chemicals in it which are detrimental to pipes and hot-water heaters, and the supply has been so limited in dry seasons that the chief industry of the town, the Nickel Plate Railroad, has threatened to remove its terminal.

The system for the disposal of sewage in Bellevue is unique. Natural and artificial sink holes are relied upon entirely. One natural sink accommodates as many as 12 houses, while an artificial sink accommodates from one to three. When an artificial sink is made, a well-driller bores a hole through the limestone bedrock until a wet crevice is reached. The city fire department is then called upon to test it. Water is poured down it and if the crevice can take the water as fast as it is given, the hole is pronounced satisfactory; if not, the well-driller continues to a crevice which does prove satisfactory. When the hole is found satisfactory, a perforated 6-inch iron pipe is inserted into the top and an area about 5 feet across and 10 feet deep is cemented or bricked for a cesspool. The perforated iron pipe has a plunger which can be worked occasionally without removing the heavy cement cover of the sink hole. Thus some of the surface wash and large articles are prevented from filling it up. However, frequently sink holes become choked with sediment and the owner of the property is burdened with the expense of re-drilling the hole. The deepest drilled sinks are found northwest of town around Euclid Avenue. A common depth is around 60 or 70 feet.

During the season of spring and fall rains the sink holes are not sufficient. The streets in the lower sections of the town are often flooded for several hours at a time and basements then have from one to three feet of unclean water at a time.

In 1913 and 1936 the spring rains in this and bordering regions to the south were exceptionally heavy. As a result, many of the sink holes became fountains and the surrounding areas became lakes. The water was six to twelve feet deep in some streets in the southern part of town. Here currents of considerable force caused damage to lawns

and property. Depressions not more than a foot across and a few inches deep developed into holes 20 feet or more across and three or four feet deep during these floods. The present sink hole method of handling the sewage is a menace to public health. Consequently, an order from the State Board of Health to install a sanitary sewage system may end it at any time.

The citizens of Bellevue are aware that the water supply problems and sewage disposal system are of growing importance. It is probable that in the near future Bellevue may draw upon Lake Erie for a better and more dependable supply of water.

Immediately to the west of Bellevue a settlement of a semi-rural character follows the ridge and well-drained sand dune area bordering the Maumee Pike. Because of their proximity most of the inhabitants consider Bellevue their chief shopping center.

Bellevue occupies a favorable position with relation to population centers of the United States which furnish markets for the manufactured and quarry products. The numerous railroads and hard-surfaced motor roads form excellent regional connections with these markets. Trucks do a large part of the hauling.

The metropolitan influence of Cleveland, Sandusky, and Toledo, may be seen in various features on the local landscape. The greater volume of traffic (especially the preponderance of freight traffic between Toledo and Cleveland) on the roads leading to these cities suggests their nearness and market value. Because of the proximity of these cities and excellent transportation facilities, their newspapers are distributed daily in Bellevue. The metropolitan influences are not all particularly beneficial. Local retail merchants as well as the chain stores depend upon the wholesale concerns in Cleveland and Toledo for their supplies because the improved transportation facilities allow this. The retail dry goods stores carry a limited stock of goods because much shopping is done in these larger cities. Shopping News from Cleveland is distributed weekly.

## CONCLUSION

Bellevue resembles in history and development many towns of Ohio. It differs from a large number in having, especially in its early decades, a good roadway along the several old beaches. Beach towns, though on abandoned beaches, are quite different commercially from lake towns. Bellevue is unique in its water and sewage developments. Other towns along the north-south sink hole belt might have similar problems, but there were no other beaches across this belt to call for towns, hence Bellevue can be called unique in location and in its peculiar adjustments to its unique situation.

## BIBLIOGRAPHY

(1) **Baughman, A. J.** History of Huron County, Vol. I. S. J. Clarke Pub. Co., Chicago. 1909.
(2) **James, Preston E.** The Terminology of Regional Description. Assoc. American Geog. XXIV, 78–92. 1934.
(3) **Jones, Wellington D.** Procedures in Investigating Human Occupance of a Region. Assoc. Amer. Geog. XXIV, 93–112. 1934.
(4) **Kemp, Harold S.** Queen City of the Lakes, A Geog. Pageant. Jour. Geog. XXX, 93–110. 1931.
(5) **Meek, Basil.** 20th Century History of Sandusky County, Ohio, and Representative Citizens. Richmond-Arnold Pub. Co., Chicago. 1909.
(6) **Orton, Edward, Jr.,** and **Samuel V. Peppel.** Limestone Resources and Lime Industries in Ohio. Geol. Survey, Ohio 4th Series, Bull. 4. 1906.
(7) **Read, M. C.** Geology of Huron County, pp. 289–309, Geol. Surv. Ohio; Vol. III, Part I. Columbus, Ohio. 1878.
(8) **Whittlesey, Derwent.** Metropolitan Districts, Population and Area. Jour. Geog. 32, 334–337. 1933.
(9) **E. F. Warner.** Pioneer Days and Settlement: The Makers of Sandusky County, pp. 98–145.
(10) **E. F. Warner.** Bellevue Village and York Township, pp. 350–355.
(11) **N. H. Winchell.** Geology of Sandusky County, pp. 591–610, Geol. Surv. of Ohio; Vol. I, Part I. Columbus, Ohio. 1873.

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### Physiological Chemistry

The sixth edition of this text is a revised, enlarged and up to date version of biochemistry. It is presented from a broad biological viewpoint and in a manner which arouses the student's interest by challenging his scientific imagination.

The book is ideally suited to the needs of medical students in its selection, arrangement and emphasis of material. Its greatest asset, however, is that it leaves the medical student with an integrated picture of the various phases of body chemistry and thereby provides him with a basis for understanding later courses in normal and pathological physiology and the rationale of therapy.

The section on Laboratory Methods has been omitted from this edition and has been published separately by The Williams and Wilkins Company as "Practical Methods in Biochemistry" by F. C. Koch.—*M. M. Parker.*

**Physiological Chemistry,** Sixth Edition, by Albert P. Mathews. xvi+1488 pp. Baltimore, The Williams and Wilkins Co. 1939. $8.00.

# BLACK WIDOW SPIDER (LATRODECTUS MACTANS FAB.) DISTRIBUTION IN OHIO

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In the winter and spring of 1940 the author made a survey of the distribution of the black widow spider (*Latrodectus mactans* Fab.) in the state of Ohio from his records and from those of nearly forty collaborators—biologists and naturalists from all parts of this state.[1] A summary shows that specimens have been reported from thirty-two counties, although prior to this survey, specimens had been reported from but three counties.[2] The black widow spider is limited in its distribution in Ohio to the eastern and southern sections and is not found more than twenty-five miles beyond (i. e., to the west and north) the borders of the hilly area (the unglaciated Allegheny Plateau and the eroded Ohio River region of southwestern Ohio)—an area with fairly even black widow spider distribution, bounded in general by the Ohio River from Cincinnati to East Liverpool and beyond to Youngstown, on one hand, and by the following cities on or near the margin of the hilly region of the state, on the other, Hamilton, Chillicothe, Lancaster, Newark, Mt. Vernon, New Philadelphia, Youngstown.

The author, who is collecting spiders in eastern Ohio, has found in this area black widow spider specimens largely under small, loose rocks which have become shelved through soil erosion, on dry, bare hillsides, or under objects on well-drained, sandy soil; collaborators have reported similar experiences, the exception usually being a building where the spider has found similar conditions. As the western Ohio prairie region and the relatively level northern part of the state apparently do not have this spider, it seems logical to conclude that the black widow spider prefers the dry surroundings afforded by areas that have rapid water drainage.

[1]An exhibit including map and legend was presented at the Semi-Centennial Celebration of the Ohio Adcaemy of Science in the spring of 1940.

[2]Barrows, W. M. 1918. A List of Ohio Spiders. O. Jr. Sci. 18, No. 8: 303.

# NINE NEW COLEOPTERA

## (Plastoceridae, Buprestidae and Cerambycidae)

JOSEF N. KNULL
The Ohio State University

**Plastocerus jeffersonianus** n. sp.

*Male.*—Narrow elongate, pronotum, and entire ventral surface including legs yellow. Head, antennae and scutellum dark brown, elytra black.

Head convex, front depressed; surface densely coarsely punctured, pubescent; eyes prominent hemispherical; antennae reaching to basal portion of elytra when laid along side of pronotum, scape stout, second joint wider than long, third joint same size, fourth joint longer than wide, following joints increasing in length, eleventh joint longest, joints four to ten inclusive with appendages, length of outer modified parts nearly three times length of segments, joints densely pubescent.

Pronotum about as long as broad, widest at base, constricted at apex; sides nearly parallel at apex, expanded at middle, sinuate at base, hind angles divergent; disk convex, prehumeral and lateral marginal carinae absent; surface coarsely punctured, punctures slightly smaller than those of head, pubescence of same length and density as that of head. Scutellum rectangular, depressed in middle, densely finely punctured.

Elytra wider than pronotum, widest at base; sides rounded in front, constricted about middle, apices acutely rounded; disk convex; surface striate, punctures of striae larger than those of pronotum, interspaces convex, finely punctured, punctures same size as those of scutellum, pubescence same length and density as on pronotum.

Abdomen beneath densely finely punctured, punctures more numerous on last segment, pubescence same length as on elytra, last segment acutely rounded. Prosternum coarsely punctured, a transverse carina in middle, posterior median carina lacking. Hind tarsi long, shorter than tibiae.

Length 9.7 mm.; width 2.6 mm.

Described from specimen in the collection of the writer taken in the Davis Mountains, Jeff Davis Co., Tex., July 2, 1940, by D. J. and J. N. Knull.

According to Van Dyke's key[1] this species would run to *P. granti* Schffr. It can be separated by the color and lack of longitudinal median prosternal carina.

**Plastocerus coronadi** n. sp.

*Male.*—Elongate, dark brown with exception of abdomen which is yellow.

[1]E. C. Van Dyke, Proc. Cal. Acad. Sci., v. 10, No. 9, pp. 1–465, 1932.

Head convex, coarsely, densely punctured, densely pubescent; eyes prominent, hemispherical, antennae reaching to basal portion of elytra when laid along side of pronotum, scape stout, second joint broader than long, third joint as long as broad, fourth joint longer than third, following joints increasing in length, eleventh joint longest, constricted near tip, joints four to ten inclusive with appendages, length of outer modified parts over three times length of segments, joints densely pubescent.

Pronotum as long as broad, widest at base, apex narrower; sides rounded in front, parallel to near base, hind angles divergent; disk convex, prehumeral carinae rather indefinite, lateral marginal carinae extending full distance; surface coarsely densely punctured, punctures separated by less than their own diameters, same size as those of head, pubescence of same density as on head. Scutellum nearly square, depressed vertically, punctures same size as elytral interspaces.

Elytra much wider than pronotum, widest at umbone; sides rounded in front, slightly constricted about middle, apices acutely rounded; disk convex; surface striate, punctures of striae half the size of those on pronotum, interspaces convex, granulate, densely punctured, punctures smaller than those of striae, pubescence of same density as on pronotum only shorter.

Abdomen beneath densely finely punctured, punctures more numerous on last segment, pubescence same length as on elytra, last segment broadly rounded. Prosternum coarsely punctured, a prominent median carina in rear joining a transverse carina in middle. Hind tarsi long, shorter than tibiae.

Length 12.6 mm.; width 3 mm.

Described from four male specimens collected in Lincoln Co., N. M., July 19, 1940, by D. J. and J. N. Knull. Type material in collection of writer.

Variations.—One paratype has a yellow prothorax.

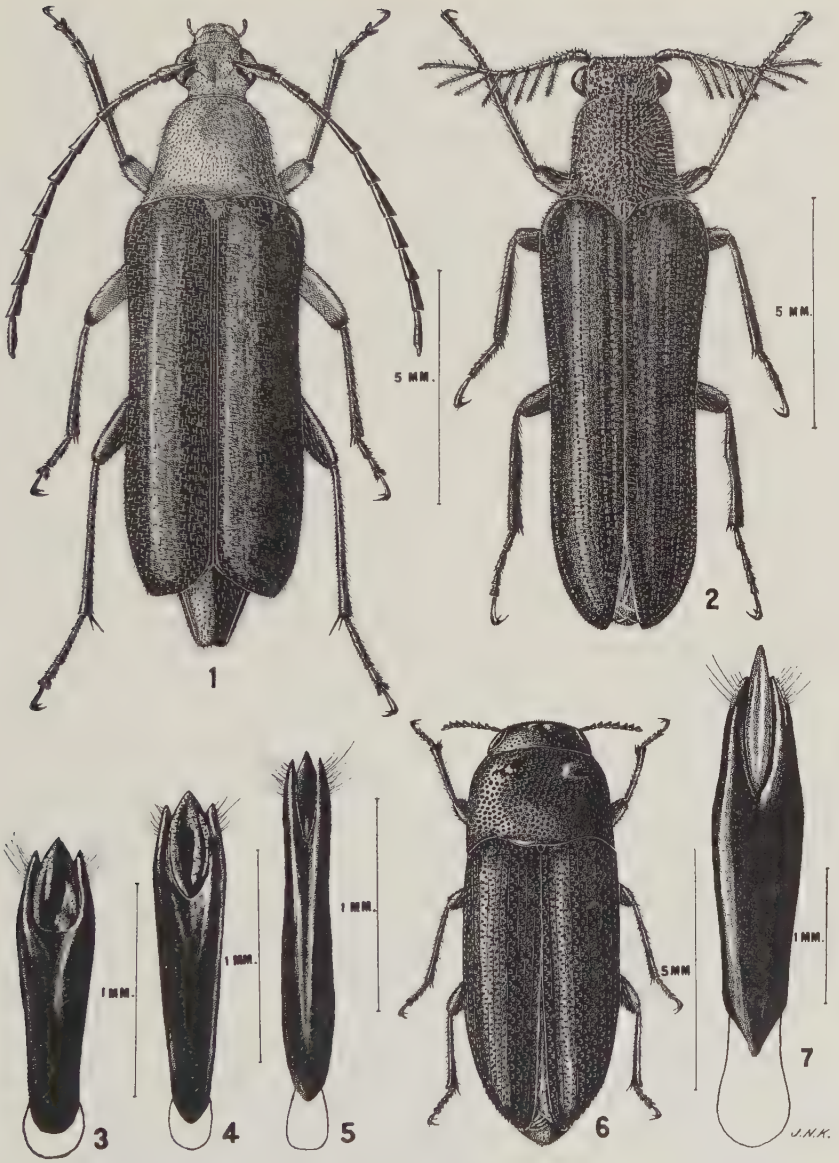
According to Van Dyke's key[1] this species would run to *P. megalops* Fall. It can be separated by the color and smaller eyes.

**Agrilus cliftoni** n. sp.

*Male.*—Resembling *A. masculinus* Horn in size, form and color; antennae, head, pronotum and legs bronzy green, elytra piceous with bronzy lustre, beneath dark bronze.

Head convex, with slight median depression on vertex; surface granulose on front, vertex coarsely punctate; antennae not extending to middle of pronotum when laid along side margins, serrate from the fourth joint.

Pronotum wider than long, wider at apex than at base, widest in front of middle; sides arcuately rounded in front, then obliquely narrowed to base; when viewed from the side, marginal and submarginal carinae separated in front, joined near base; anterior margin strongly sinuate, median lobe broadly rounded; base transversely bisinuate, median lobe not produced and arcuately emarginate in front of scutellum; disk convex, with two median transverse depressions, a lateral depression each side, prehumeral carinae well defined; surface densely




1. *Euryptera texana* n. sp.
2. *Plastocerus coronadi* n. sp.
3. Male genitalia of *Agrilus davisi* n. sp.
4. Male genitalia of *Agrilus patagoniensis* n. sp.
5. Male genitalia of *Agrilus cliftoni* n. sp.
6. *Hippomelas pygmaea* n. sp.
7. Male genitalia of *Hippomelas femorata* n. sp.

transversely rugulose, fine punctures between rugae. Scutellum transversely carinate.

Elytra at base wider than base of pronotum; sides parallel near base, constricted in front of middle, expanded back of middle, apices rounded, serrulate; disk convex, sutural margins elevated back of middle, basal depressions prominent, an obsolete costa on each side; surface imbricate, pubescence not distinct.

Abdomen beneath coarsely punctate, first two abdominal segments only slightly flattened, lateral margins of first two adbominals distinct; pygidium without projecting carina. Prosternal lobe declivous, deeply emarginate in front; prosternal process wide, sides parallel to behind the front coxae, then obtusely rounded. Tibiae of first two pairs of legs mucronate on inner sides at apices, posterior tibiae not mucronate. Posterior tarsi not as long as tibiae, first joint not as long as the following joints united. Tarsal claws cleft at middle, outer tooth acute at apex, inner broader and turned inward, tips touching, claws similar on all feet.

Length 5.7 mm.; width 1.4 mm.

Described from one male specimen collected at Clifton, Ohio, May 30, 1939, by D. J. and J. N. Knull, in the collection of the writer.

According to Fisher's key[2] this species would run to *A. arcuatus* (Say), however the genitalia will serve to separate it.

**Agrilus patagoniensis** n. sp.

*Male.*—Robust, dark cupreous above and below; head, sides of pronotum and a vitta on each elytron clothed with white recumbent pubescence.

Head deeply impressed; surface coarsely, densely punctured, rugose; antennae reaching to beyond middle of pronotum when laid along side margins, serrate from the fifth joint.

Pronotum about as long as wide, wider at apex than at base; sides nearly straight, narrowed posteriorly; when viewed from the side the marginal and submarginal carinae are united at base; anterior margin sinuate, median lobe broad; base strongly emarginate at middle of each elytron; disk convex, lateral depressions deep, a broad transverse depression at base, prehumeral carinae tuberculate, not sharp; surface coarsely transversely rugose, finely punctured between the rugae. Scutellum glabrous, lacking transverse carina.

Elytra at base as wide as base of pronotum, widest back of base; sides nearly parallel at base, constricted at middle, widened back of middle, apices rounded, serrulate; disk convex, sutural margins elevated back of middle, basal depressions deep, surface coarsely imbricate.

Abdomen beneath finely punctate, clothed with recumbent white pubescence; first and part of second segment flattened at middle; pygidium without projecting carina. Prosternum densely punctured, pubescent, pubescence extending along median line to second abdominal; prosternal lobe broadly rounded in front; prosternal process

[2]W. S. Fisher, U. S. Nat. Museum Bul. 145, pp. 1–347, 1928.

expanded back of coxal cavities. Tibiae on first two pairs of legs mucronate on inside at apices. Posterior tarsi slightly shorter than tibiae, first joint shorter than the three following joints together. Tarsal claws cleft, the inner teeth not turned in, posterior tarsi with inside teeth much shorter than outer ones.

Length 7 mm.; width 1.8 mm.

*Female.*—Tibiae not mucronate, middle portions of first two ventral abdominal segments convex.

Holotype collected in the Patagonia Mountains, Arizona, July 22, 1940, by D. J. and J. N. Knull. Allotype labeled Nogales, Ariz., July 30, 1937, E. D. Ball. Type material in writer's collection.

According to Fisher's key[2] this species would run to *A. felix* Horn, but the smooth scutellum, coarsely rugose pronotum, lack of sharply defined prehumeral carinae and shape of the male genitalia will distinguish it.

**Agrilus davisi** n. sp.

*Male.*—Slightly more robust than *A. egenus* Gory; shining cupreous above; bronzy green beneath; front green, a post-median pubescent spot in center of each elytron.

Head convex, narrow median groove on vertex; surface finely granular, rugose on vertex; antennae reaching to about middle of pronotum when laid along side, serrate from the fifth joint.

Pronotum wider than long, wider at apex than at base, widest at apex; sides obliquely narrowed toward base, sinuate near hind angles; when viewed from the side, marginal and submarginal carinae are united near base; anterior margin strongly sinuate, median lobe broad; base sinuate; disk convex, with slight median depression in front of scutellum, lateral depressions strong, prehumeral carinae well indicated; surface transversely rugose, punctures distinct between the rugae, lateral depressions pubescent. Scutellum finely granulate, transversely carinate.

Elytra at base wider than base of pronotum, widest on basal fifth; sides broadly rounded in front, constricted at middle, expanded back of middle, apices rounded, serrulate; disk with sutural margins elevated back of middle, basal depressions well marked; surface imbricate, pubescence inconspicuous.

Abdomen beneath finely punctate, punctures connected by fine transverse lines, pubescence inconspicuous, first segment concave at middle, second segment flattened, pygidium without a projecting carina. Prosternum finely punctate, clothed with long pubescence which extends along median line to second abdominal segment; prosternal lobe truncate. Posterior coxae with hind margin sinuate, exterior angle obtuse and prolonged. Tibiae of first two pairs of legs mucronate on inside at apices. Posterior tarsi not longer than tibiae, first joint not as long as three following joints united. Tarsal claws somewhat similar on all feet, cleft, the inner tooth broad, shorter than outer one and not turned inward.

Length 5.8 mm.; width 1.7 mm.

Holotype collected in the Davis Mountains, Tex., July 1, 1940, by D. J. and J. N. Knull in the collection of the writer.

This species runs to *A. barberi* Fisher in Fisher's key.[2] It may be separated by its more rugose sculpture of pronotum and by the shape of the male genitalia.

**Hippomelas femorata** n. sp.

*Male.*—Elongate, robust, dull brassy throughout.

Head convex, coarsely irregularly punctured, punctures finer on vertex, front with median carina flanked by irregular smooth callosities, pubescence sparse; antennae reaching to basal fourth of elytra when laid along side of pronotum, scape not wider than other joints, second joint as long as wide, third joint as long as scape, following joints decreasing to eleventh inclusive, serrate from the fourth joint.

Pronotum wider than long, widest in middle, wider at base than at apex; sides broadly rounded from apex to base; lateral marginal carina inferior in apical fourth; disk convex with two slight depressions on each side in front of humeral angles; surface coarsely, irregularly punctured, spaces between punctures forming irregular smooth areas, pubescence lacking. Scutellum very small, somewhat obscured by pronotum.

Elytra wider than pronotum, widest back of humeral angles; sides rounded in front, constricted in middle, broadly rounded to truncate apices; margins not serrate; disk convex; surface coarsely punctured, punctures smaller than those on pronotum, each elytron with five indistinct costae, giving the elytra a rugose appearance, pubescence short, sparse.

Abdomen beneath finely densely punctured, pubescent; last ventral broadly rounded. Femora of posterior legs stout, tarsi more than half the length of tibiae, second and third joints together longer than first.

Length 11.8 mm.; width 4 mm.

Holotype labeled Potrero, San Diego Co., Calif., Aug. 11, 1940, D. J. and J. N. Knull collectors, in collection of writer.

The narrow elongate form of this insect makes it resemble *Nanularia californica* (Horn). It is quite distinct from other allied forms in its robust femora and the shape of the internal genitalia.

**Hippomelas pygmaea** n. sp.

*Female.*—Robust, cupreous above and below.

Head convex; surface rugose, a smooth callosity on front, pubescence short, inconspicuous; antennae short, not reaching middle of pronotum when laid along side margin, scape stout, second joint much shorter, third joint as long as scape, fourth joint shorter than third, following joints decreasing in length to eleventh, joints four to eleven serrate.

Pronotum wider than long, widest basally, constricted at apex; sides broadly rounded in front, parallel on basal two-thirds; anterior margin nearly straight, basal margin trisinuate, median lobe broad; disk convex, a transverse depression in front of scutellum, a smooth callosity on each side in front, lateral margin present on basal half

only; surface very coarsely, irregularly punctured, pubescence absent. Scutellum small, triangular, longitudinally depressed in middle.

Elytra wider than pronotum, widest in apical third; sides rounded in front, constricted about middle, broadly rounded posteriorly to rounded apices, margins serrate in apical half; disk convex, a basal depression on each elytron near humeral angle; surface striate, punctures of intervals large, smaller than those of pronotum, irregularly placed, pubescence absent.

Abdomen beneath finely densely punctured, pubescent; last abdominal rounded at apex, surface rugose. Posterior tarsi a little over half the length of tibiae.

Length 8 mm.; width 3 mm.

Holotype labeled Val Verde Co., Tex., June 28, 1940, D. J. and J. N. Knull collectors, in collection of writer.

This species differs from *Nanularia californica* (Horn) by the robust form, lack of pubescence and large punctures on dorsal surface, rounded elytral apices and short posterior tarsi.

**Pachyschelus uvaldei** n. sp.

*Male.*—Form and size of *P. laevigatus* (Say); color of head, pronotum and scutellum shining black with slight violaceous reflection, elytra dark violaceous, black beneath.

Head convex, with slight depression on front; surface very finely punctured, punctures becoming obsolete on vertex, void of pubescence.

Pronotum over three times as wide as long, widest at base, narrowest at apex; sides broadly rounded from apex to base, hind angles produced; disk convex, a slight lateral depression at base on each side; surface minutely punctured in center, punctures more numerous along sides, short pubescence along sides. Scutellum triangular, glabrous.

Elytra at base narrower than base of pronotum, widest at base; sides broadly rounded to rounded apices, tips serrulate; disk convex, each elytron with a basal depression and another lateral depression back of umbone; surface with moderate punctures arranged somewhat in rows, each puncture bearing a minute recumbent hair, longer white pubescence in basal depressions of each elytron, a median diagonal band broken at the middle and a diagonal band at apical third which does not run to suture.

Abdomen beneath shining, minutely punctured and pubescent; last abdominal with apical depression, margin with three teeth, the two inner ones somewhat united.

Length 2.5 mm.; width 1.6 mm.

*Female.*—Last ventral obtusely rounded with a spine at apex.

Holotype male, allotype and paratypes collected from *Acalypha hederacea* Torr.[3] in Uvalde Co., Tex., June 26–27, 1940; paratypes from Val Verde Co., Tex., June 28, 1940, by D. J. and J. N. Knull. Type material in collection of writer, paratype in The Ohio State University collection.

[3]Determined by Dr. F. W. Pennell.

This species may readily be separated from any of our other forms by the placement of the elytral pubescence.

**Euryptera texana** n. sp.

*Female.*—Form elongate, black, with exception of head, thorax, scutellum, mesasternum, anterior and middle femora, which are yellow.

Head densely finely punctured, pubescence not conspicuous; antennae reaching beyond middle of elytra when laid along side of pronotum, scape stout, second joint as long as wide, third shorter than first, fourth shorter than third, fifth longer than third, following joints decreasing in length to eleventh which is longer than tenth; second, third and fourth joints slender.

Pronotum wider than long, much narrower at apex than at base, widest at base, sides broadly rounded in front, expanded toward base, hind angles acute; disk convex, with slight basal depression on each side, a transverse depression in front of scutellum; surface densely punctured, each puncture bearing a recumbent hair. Scutellum triangular, densely punctured and pubescent.

Elytra wider than base of pronotum, widest at humeral angles; sides nearly parallel, apices rounded, with obtuse angle at outer side of curve; disk convex; surface densely finely punctured, each puncture bearing a recumbent hair.

Abdomen beneath sparsely punctured in middle, punctures dense along sides.

Length 11.5 mm.; width 3 mm.

Described from one specimen collected in the Davis Mountains, Texas, July 3, 1940, by D. J. and J. N. Knull. Holotype in collection of writer.

Aside from color this species differs from *E. ignita* (Schffr.) by the more finely punctured pronotum. From *E. cruenta* Martin it differs by having larger punctures on elytra than pronotum.

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**Textbook of Zoology**

The largest difference between this edition and the previous one is the addition of a chapter on ecology; the remainder of the book is essentially the same brought up-to-date. The new chapter is that sort of ecology which is largely a recitation and classification of relationships between animals and their environments. The factors operating to bring about these circumstances receive little attention. It would seem that selection of essential information from the chapters Interpreting Animals, Interpreting Plants, and Ecology, and its arrangement into an orderly system would have produced a section of greater merit. The tinted paper, new type, and colorful binding make a very attractive book.—*Carl Venard.*

**Animal Biology,** by Michael F. Guyer. xix + 723 pp. 423 figs. 3rd ed. New York, Harper and Brothers. 1941. $3.75.

# HYDROGEN-ION CONCENTRATION AND THE INITIATION OF GROWTH

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Experiments have been carried out in the past on the effect of hydrogen-ion concentration on the initiation of growth, using the spores of many fungi and the pollen grains of a few angiosperms. Likewise, work has been reported, using fungus spores, potato tuber tissue, fungus mycelium, root tips, and succulent cactus tissue, which indicates that the protoplasm of plant tissue behaves as though it were a protein with a definite isoelectric point. This behavior has been determined on the basis of water absorption, the behavior of the tissue in relation to staining with acid and basic dyes, and by the effect of the tissue upon the reaction of solutions in which it is immersed. The literature dealing with these points will be considered briefly in connection with the discussion of the results of the present experiments.

The experiments reported in this paper are concerned with the effect of hydrogen-ion concentration upon the germination of the spores of *Rhizopus suinus* Niels. and upon the sprouting of the tubers of the potato, *Solanum tuberosum* L.

## EXPERIMENTAL

I. The influence of hydrogen-ion concentration upon the germination of the spores of *Rhizopus suinus* Niels.

The buffer solutions used for the germination tests were made up after the method of Webb (14). Phosphoric acid and potassium hydroxide were made up in m/5 concentrations, both solutions containing mannitol in a concentration of m/5. The two solutions were combined in various proportions to give a wide range of hydrogen-ion concentrations and were sterilized in the autoclave for 15 minutes at 15 pounds pressure.

The spore suspensions were prepared after the method of Tilford (11). Thirteen different buffer solutions, each with a volume of 15 cubic centimeters, were used to remove the spores from an equal number of agar slant cultures of the fungus. The hydrogen-ion concentrations of the solutions were redetermined after the spores were taken up in order to be sure that there was no change in pH as a result of absorption of

materials from the agar slants. The values given in the tables for the hydrogen-ion concentrations of the different solutions are these redetermined values.

TABLE I

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE GERMINATION OF THE SPORES OF *Rhizopus suinus*

| Tube Number | pH | Percentage of Spore Germination |
|---|---|---|
| 1 | 1.2 | 0.0 |
| 2 | 2.2 | 22.3 |
| 3 | 3.3 | 36.6 |
| 4 | 4.0 | 67.6 |
| 5 | 5.0 | 17.6 |
| 6 | 5.7 | 90.0 |
| 7 | 6.2 | 80.0 |
| 8 | 7.0 | 50.0 |
| 9 | 7.6 | 27.8 |
| 10 | 8.0 | 16.5 |
| 11 | 8.8 | 12.6 |
| 12 | 9.3 | 5.8 |
| 13 | 10.0 | 0.0 |

TABLE II

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE GERMINATION OF THE SPORES OF *Rhizopus suinus*. SECOND SERIES.

| Tube Number | pH | Percentage of Spore Germination |
|---|---|---|
| 1 | 1.1 | 0.0 |
| 2 | 2.4 | 21.0 |
| 3 | 3.1 | 30.0 |
| 4 | 4.2 | 61.1 |
| 5 | 4.6 | 43.0 |
| 6 | 5.6 | 94.8 |
| 7 | 6.5 | 58.1 |
| 8 | 7.2 | 31.0 |
| 9 | 7.8 | 23.1 |
| 10 | 8.6 | 11.0 |
| 11 | 9.0 | 5.3 |
| 12 | 10.0 | 0.0 |

Hanging drop cultures were made from each tube. Evaporation from the drop was prevented by placing a small quantity of the non-inoculated buffer of the same pH in the bottom of the cell and by sealing the cover glass to the cell with vaseline.

After twenty-four hours the spore germination counts were made. Five fields were counted from each cell, and three cells were used for each pH value. In all, a total of about five hundred spores at each pH were counted, and the percentage of germination was calculated. The production of germ tubes was taken as the sole criterion of germination, those spores which merely showed swelling being disregarded. The results of the first series are contained in Table I.

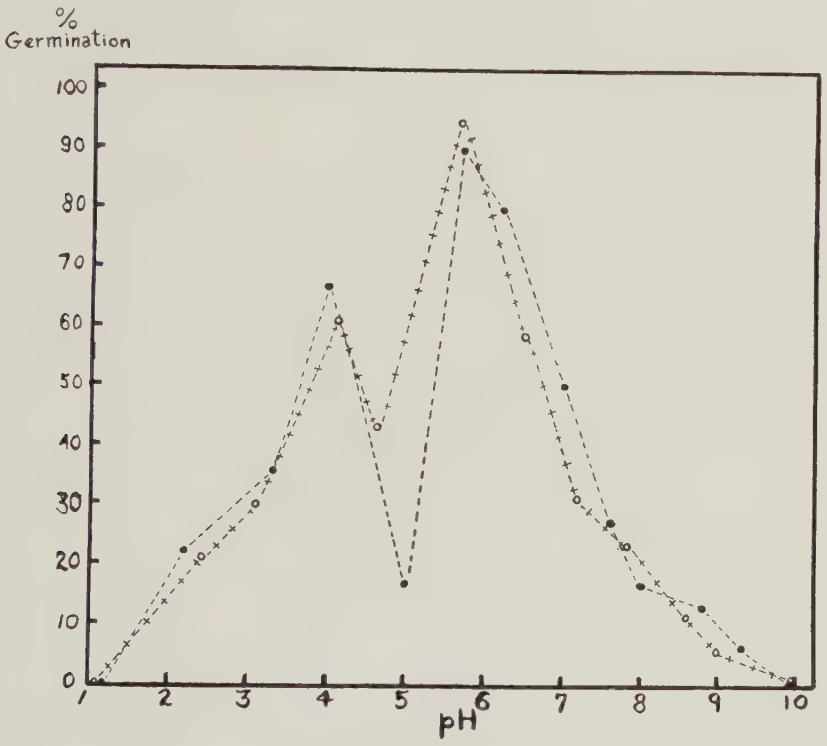


Figure 1. The effect of hydrogen-ion concentration upon the germination of the spores of *Rhizopus suinus*. Series one is represented by the broken line with closed circles; series two by the crossed line with open circles.

In a second series of experiments, which were carried out exactly as described above, except that the hydrogen-ion concentrations of the different solutions varied a little from the values used in the first series, very similar results were obtained. These results are given in Table II.

In figure 1 the percentage of spore germination is plotted against hydrogen-ion concentration expressed as pH. The results of both curves are used. Although the two curves are apparently somewhat different, it may be seen that it is possible to obtain from the two curves a single smoothed curve passing through the important points of both experimental curves.

II. The effect of hydrogen-ion concentration on the sprouting of tubers of *Solanum tuberosum* L.

The further influence of the concentration of hydrogen-ions on the initiation of growth was demonstrated through the use of potato tubers. The experiments were carried out in the late spring, in order to eliminate from consideration the factor of dormancy.

The buffers used in these experiments were prepared from an m/5 solution of monobasic potassium phosphate and an m/10 solution of citric acid. These solutions were mixed in varying proportions to give a series of fifteen buffer mixtures, ranging in hydrogen-ion concentration from that equal to pH 2.0 to that equal to pH 9.3.

TABLE III

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE GERMINATION OF POTATO TUBERS

| Container Number | pH | Average Sprout Length in mm. | |
|---|---|---|---|
| | | Two Weeks | Three Weeks |
| 1 | 2.0 | 0.0 | 0.0 |
| 2 | 2.3 | 0.0 | 0.0 |
| 3 | 2.5 | 0.0 | 0.0 |
| 4 | 3.0 | 0.0 | 0.0 |
| 5 | 3.5 | 0.0 | 0.0 |
| 6 | 4.0 | 0.0 | 0.0 |
| 7 | 4.5 | 13.0 | 17.0 |
| 8 | 5.0 | 8.0 | 12.0 |
| 9 | 5.5 | 8.0 | 24.0 |
| 10 | 6.1 | 7.0 | 25.0 |
| 11 | 6.5 | 9.0 | 15.0 |
| 12 | 7.0 | 4.0 | 10.0 |
| 13 | 7.9 | 9.0 | 13.0 |
| 14 | 8.5 | 10.5 | 24.0 |
| 15 | 9.3 | 8.0 | 14.0 |

Potato tubers of the Wisconsin Rural variety were cut in half, sterilized in a 0.1 per cent solution of bichloride of mercury, rinsed, and three half-tubers were immersed in each of the buffer solutions. After the twenty-four hour immersion period was completed, the tubers were removed from the buffers, resterilized in the bichloride solution, and air dried for 48 hours to promote suberization of the cut surfaces and thus to prevent rotting. These half-tubers were then placed in moist sphagnum in containers fashioned from two large pot-saucers. At the end of a two-week period, and again at the end of a three-week period, the sprouts which had developed were measured. Measurements of the apical sprouts were not taken, as these in general tend to be somewhat erratic in their behavior. The results, expressed as an average of

the sprout lengths of the three half-tubers used at each hydrogen-ion concentration are given in Table III and are shown in figure 2. A second series gave similar results.

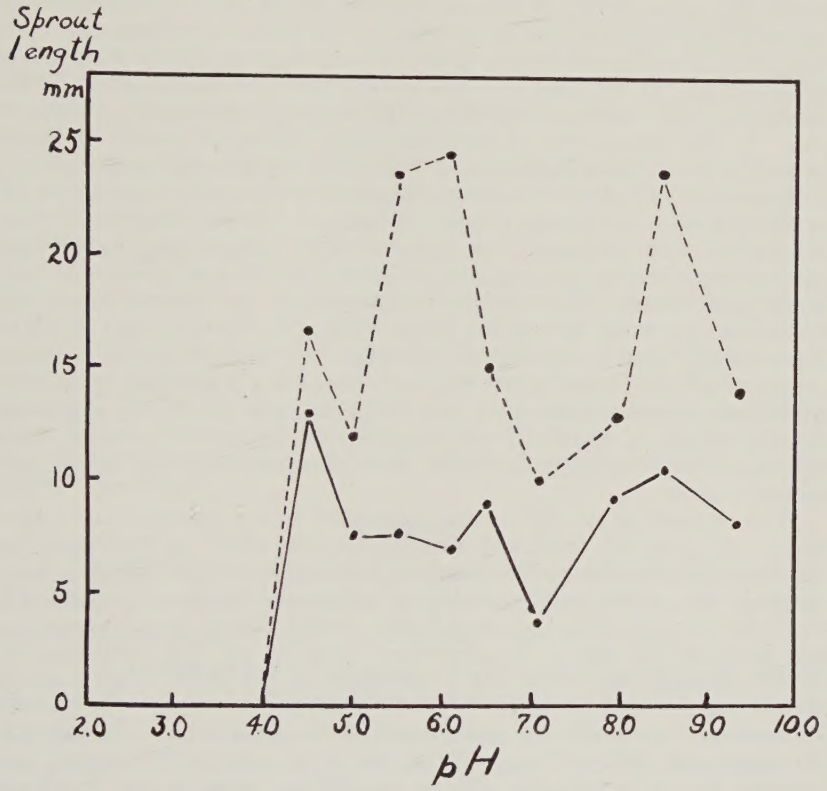


Figure 2. The effect of hydrogen-ion concentration on the sprouting of potato tubers. The solid line represents two weeks of growth; the broken line represents three weeks of growth.

## DISCUSSION

There is established by the experimental work herein reported a curve for the germination of the spores of *Rhizopus suinus* as a function of hydrogen-ion concentration which is bimodal in nature. The two maxima come at about pH 4.0 and at about pH 5.7. The point at which minimum spore germination occurs lies between these, at about pH 5.0. This minimum point has been demonstrated by other authors. Robbins (5) showed by experiments on the absorption of acid and basic dyes that the mycelium of *Rhizopus nigricans* responded much like a protein with an isoelectric point between pH 4.8 and pH 5.1, while the mycelium of *Fusarium lycopersici* responded like a protein with an

isoelectric point in the vicinity of pH 5.5. Robbins and Scott (7) determined, by means of the effect of the tissue on the reaction of solutions that the minimum point (isoelectric point) for *Fusarium oxysporum* was at pH 4.9–5.0 and that for *Gibberella saubinetii* was near pH 6.2. Scott (10) showed that *Fusarium lycopersici* exhibited a minimum in the spore germination curve at pH 5.2. Webb (13, 14) showed that there was a minimum in the spore germination curve of *Penicillium cyclopium* at pH 7.0, and a *Fusarium* sp. had a minimum point in the curve at pH 6.2. On the other hand, this same author found a minimum point in the curves for *Aspergillus niger*, *Botrytis cinerea*, *Lenzites saepiaria*, *Penicillium italicum* and *Puccinia graminis* only under certain temperature conditions. Webb was apparently the first to call attention to the phenomenon of the double maximum. Tilford (11) found that *Sclerotinia fructicola* gave a minimum of spore germination at pH 6.0, the two maxima being obtained at about pH 2.4 and about pH 6.6. Webb and Fellows (15) found a minimum in the growth curve for *Ophiobolus graminis* at pH 8.3, with maxima at pH 5.2 and pH 9.6. The criterion used for growth in this case was the diameter of colonies produced on corn meal agar. Scott (9) found for *Fusarium lycopersici* a minimum in the growth curve at pH 5.2, using as a criterion of growth the dry weight of mycelium produced by the fungus in 24 days. This minimum value is identical with that obtained (10) by spore germination tests.

The occurrence of the double maximum is not confined to fungus tissue. Pfeiffer (2) tried experiments on the effect of hydrogen-ion concentration on the germination of pollen grains. He found a minimum in the curve for the pollen of *Alopecurus pratensis* at pH 4.4, while for that of *Phaseolus multiflorus*, *Urtica dioica*, *Betula verrucosa*, and *Melandryum album* the minimum came at pH 5.2. Robbins (4) further showed that there was a minimum in the water absorption of potato tuber tissue at about pH 6.0. Robbins and Scott (7) showed an isoelectric point for soy bean root tips at pH 6.2–6.4. Ulehla (12) demonstrated that sections of the succulent tissues of *Opuntia* sp. behaved like an ampholyte with an equilibrium point in the neighborhood of pH 5.6. Salter and McIlvaine (8) found a minimum in the growth curve of wheat seedlings at pH 6.15. In the experimental work of this paper on the sprouting of potato tubers in relation to hydrogen-ion concentration, the minimum in the curve is found at pH 7.0, with the maxima at pH 6.3 and pH 8.5.

In all of these phenomena which are concerned with the initiation of growth, it is found that when the initiation of growth is considered as a function of the hydrogen-ion concentration of the medium surrounding the particular plant organ concerned, a bimodal curve is established. The exact location of the two maximum points and of the minimum point depends upon the nature of the organ concerned, the particular buffer system used, the nutrition of the growing parts, the method of determining the response to the various levels of hydrogen-ion concentrations, and finally, to the various environmental conditions under which the experiments are carried out. Of these, temperature is of special importance.

Growth, which in its initial stages at least involves merely an increase in size, is entirely dependent upon the uptake of water. Loeb (1) showed that the physical properties, such as viscosity, osmotic pressure, conductivity, and *total swelling* of such a protein as gelatin are at a minimum at the isoelectric point of pH 4.7. The point at which minimum swelling, and hence minimum growth, takes place in complicated materials such as plant tissues must be a resultant of the isoelectric points of the biocolloids of the protoplasm of the tissue. This conception is not new, having been advanced by Robbins (3, 6), Robbins and Scott (7), Scott (10), and Tilford (11).

From the experimental data reported in this paper, it is evident that the relative toxicity of the hydrogen- and hydroxyl-ion varies greatly with different tissues. In the case of the sprouting of the potato tubers, good growth took place from about pH 4.5 to pH 6.5 and from about pH 7.9 to pH 9.3, the upper limit of hydroxyl-ion concentration used. The minimum point in the curve (the isoelectric point) was determined to be at pH 7.0. On the other hand, with the spores of *Rhizopus suinus*, almost the entire curve lies below pH 7.0. Germination values above fifty per cent are obtained only between the narrow pH ranges of about pH 3.5 to pH 4.5 and about pH 5.5 to pH 7.0. The minimum point in the curve is located at pH 5.0, where the concentration of hydrogen-ions is one hundred times that at the minimum point for the potato sprouting.

## SUMMARY

1. Data for the effect of hydrogen ion concentration on the initiation of growth are given for two different types of asexual reproductive units—mold spores and potato tubers.

2. For both types of organs investigated, a bimodal curve for the effect of hydrogen-ion concentration on the initiation of growth is obtained. For the spores of *Rhizopus suinus* the minimum in the curve is at about pH 5.0. For the sprouting of the potato tubers the minimum in the curve is at about pH 7.0.

3. Hydrogen-ions are relatively more toxic to potato tissue than to the spores of *Rhizopus suinus;* hydroxyl-ions are relatively more toxic to the spores of *Rhizopus suinus* than to the potato tissue.

4. The effect of the hydrogen-ion concentration on the initiation of growth is considered to be directly related to the effect of hydrogen-ion concentration upon the hydration of the biocolloids of the protoplasm of the plant tissues concerned.

## LITERATURE CITED

(1) **Loeb, Jacques.** Proteins and the Theory of Colloidal Behavior. New York. 1924.

(2) **Pfeiffer, Hans.** Kleine Beiträge zur Bestimmung des IEP von Protoplasm. II. Keimungsversuche mit Pollen im Vergleich mit refraktrometrischen Messungen. Protoplasms 12: 268–278. 1931.

(3) **Robbins, W. J.** The Analogy between Plant Tissue and a Protein. Proc. Inter. Cong. Plant Sci. 2: 1125–1138. 1929.
(4) **Robbins, W. J.** An Isoelectric Point for Plant Tissue and its Significance. Amer. Journ. Botany 10: 412–439. 1923.
(5) **Robbins, W. J.** Isoelectric Points for the Mycelium of Fungi. Journ. Gen. Physiol. 6: 259–272. 1923.
(6) **Robbins, W. J.** The Isoelectric Point for Plant Tissue and its Importance in Absorption and Toxicity. Univ. Missouri Studies in Botany 1: 1–60. 1926.
(7) **Robbins, W. J.** and **Irl T. Scott.** Further Studies in Isoelectric Points for Plant Tissue. Journ. Agric. Res. 31: 385–399. 1925.
(8) **Salter, R. M.** and **T. C. McIlvaine.** Effect of the Reaction of the Solution on Germination of Seeds and Growth of Seedlings. Journ. Agric. Res. 19: 73–96. 1920.
(9) **Scott, Irl T.** Hydrogen-ion Equilibrium of Mycelial mats of *Fusarium Lycopersici* in Salt Solutions and its Relation to Growth and Toxicity. Amer. Journ. Botany 16: 631–643. 1929.
(10) **Scott, Irl T.** Some Protein Analogies of the Mycelium of *Fusarium Lycopersici*. Missouri Agric. Exper. Sta. Res. Bull. 92. 1926.
(11) **Tilford, P. E.** The Relation of Temperature to the Effect of Hydrogen- and Hydroxyl-ion concentration on *Sclerotinia Fructicola* and *Fomes annosus*. Spore Germination and Growth. Ohio Agric. Exper. Sta. Bull. 567. 1931.
(12) **Ulehla, V.** Die Regulation der Wasserstoffionenkonzentration durch Sukkulentengewebe. Ein Beitrage zur Frage des isolektrischen Punktes der Pflanzenzelle. Protoplasma 3: 469–506. 1928.
(13) **Webb, R. W.** Studies in the Physiology of the Fungi. X. Germination of the Spores of Certain Fungi in Relation to Hydrogen Ion Concentration. Annals. Missouri Botan. Gard. 6: 201–222. 1919.
(14) **Webb, R. W.** Studies in the Physiology of the Fungi. XV. Germination of the Spores of Certain Fungi in Relation to the Hydrogen Ion Concentration. Annals Missouri Botan. Gard. 8: 283–341. 1921.
(15) **Webb, R. W.** and **H. Fellows.** The Growth of *Ophiobolus graminis* in relation to Hydrogen Ion Concentration. Journ. Agric. Res. 33: 846–877. 1926.